City of Prescott

Wastewater Facilities Master Plan

CITY OF PRESCOTT
Everybody's Hometown

Sundog Wastewater Treatment Plant

Airport Water Reclamation Facility

Wastewater Master Plan Report

FINAL

March 2011

B&V Project # 164890

BLACK & VEATCH
building a world of difference™

In Association with
carollo

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

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City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Executive Summary

Final

In Association with

Project No. 164890

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Cygnet://164890/Executive Summary

Executive Summary

Black & Veatch in association with Carollo Engineers was retained by the City of Prescott to master plan recommended improvements to wastewater treatment facilities at the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF). The master plan includes a series of task oriented Technical Memoranda which address existing conditions, analyze improvement alternatives and present the recommended improvements. This Executive Summary is presented in two parts:

- ✓ Executive Summary of Findings and Recommendations
- ✓ Executive Summary of Technical Memoranda

EXECUTIVE SUMMARY OF FINDINGS AND RECOMMENDATIONS

Water Treatment Goals

Based on wastewater flow projections presented in the Wastewater Collection System Model Study, Carollo 2008, future build-out capacities for the Sundog WWTP and Airport WRF are 5.4 million gallons per day (mgd) and 9.6 mgd, respectively.

Wastewater treatment and water reuse effluent quality/treatment requirements are dictated by Arizona Department of Environmental Quality (ADEQ) regulations pertaining to wastewater treatment. The recent ADEQ rules require wastewater treatment plants in Arizona must meet the conditions of Best Available Demonstrated Control Technology (BADCT) (state statute). The BADCT treatment performance requirements for plants greater than 0.25 mgd capacity are essentially the same as ADEQ's treatment requirements for Class A+ water reuse applications (landscape irrigation of areas open to public access). All of the effluent from the Sundog WWTP and Airport WRF is reused or recharged. Therefore, Class A+ treatment requirements (presented below) are used to establish design effluent quality requirements for both plants.

Table ES.1 ADEQ BADCT Effluent Requirements
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

Parameters	Effluent Limits (1) Average Daily Flow >250,000 gpd
pH	6.0 - 9.0
BOD (30 day average)	< 30 mg/L
BOD (7 day average)	< 45 mg/L
TSS (30 day average)	< 30 mg/L
TSS (7 day average)	< 45 mg/L
Removal Efficiency for BOD, cBOD, TSS	85%
Total Nitrogen (as N) (2)(3)	< 10 mg/L
Fecal Coliform (3)	
Single sample maximum	23 cfu/100 mL
Four of seven daily samples in one week	Non detect
R18-11-406(B-G) constituents	Numeric water quality standards must be met
A.R.S. 49-243(I) regulated chemicals	Removal to greatest extent possible without regard to cost
Trihalomethanes	Minimize THM compounds generated as disinfection byproducts

Notes:
(1) Reference: A.A.C. R-18-9-B204.
(2) Five-month rolling geometric mean.
(3) BADCT standards allow for soil aquifer treatment if it can be proven that the required level of treatment is reached prior to effluent interfacing with the groundwater.

Existing Facilities

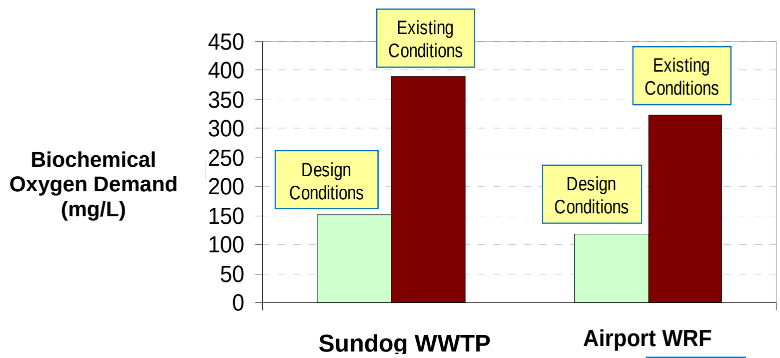
Prescott currently has three operating wastewater treatment plants; the Hassayampa Water Reclamation Plant (WRP), the Sundog WWTP and the Airport WRF. The Hassayampa WRP is privately operated year round and its effluent is used to irrigate a private golf course. The City's largest wastewater treatment plant, the Sundog WWTP, is located approximately 2 miles northeast of downtown Prescott along US Highway 89, and receives the majority of the City's wastewater flow. It was last upgraded and expanded in 1989. The Airport WRF is located roughly 8 miles northeast of the City's centroid just to the east of the local airport, Earnest A. Love Field.

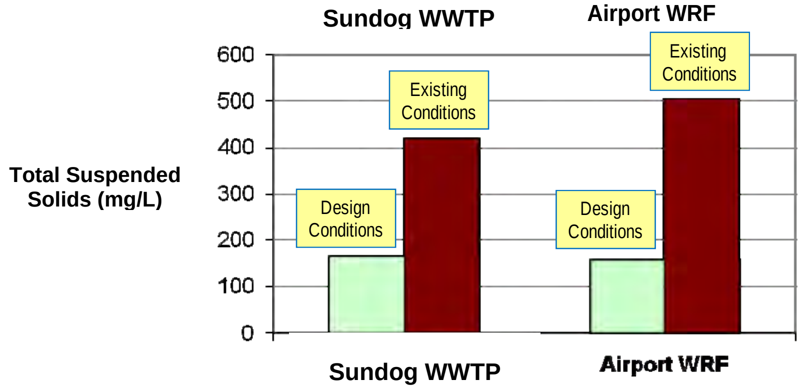
Aerial views of the Sundog WWTP and Airport WRF follow:

Sundog WWTP – Last Expanded in 1989

Airport WWTP

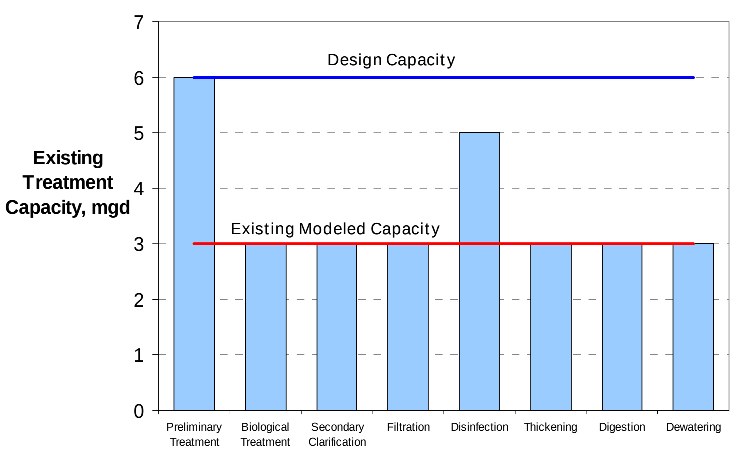
Condition assessments and analysis of existing capacity were performed for the Sundog WWTP and Airport WRF. Wastewater strength has increased in Prescott over time due to life style changes, which has been typical for communities throughout the Southwest US. For comparison, the graphics below present current wastewater strength in terms of biochemical oxygen demand (BOD) and total suspended solids (TSS) versus the strength observed when the facilities were last expanded.



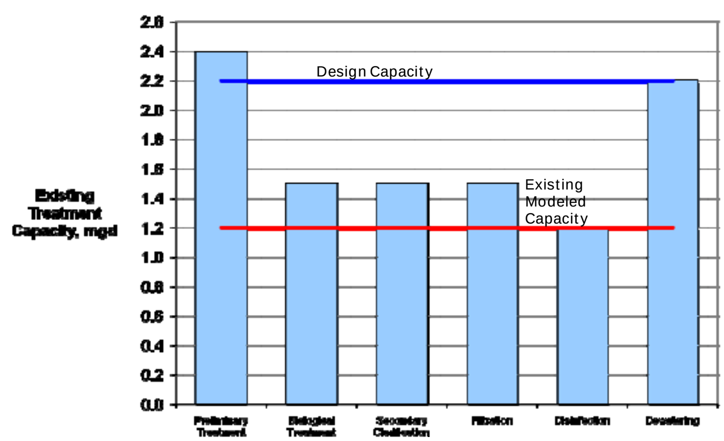


Wastewater strength has more than doubled compared to previous design values. The increase has dramatically impacted the treatment capacity of the existing facilities as shown below:

Current Treatment Capacities

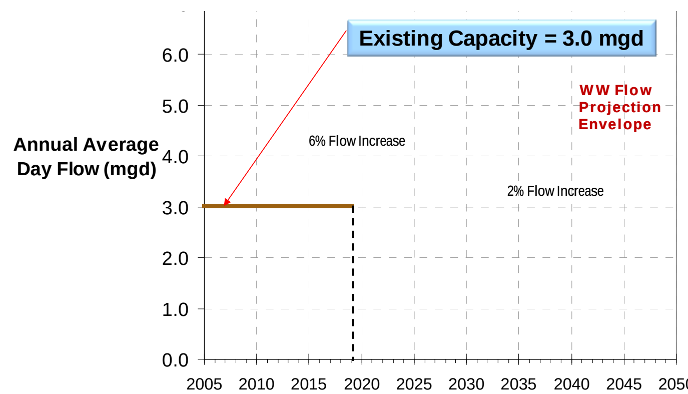


Sundog WWTP



Airport WRF

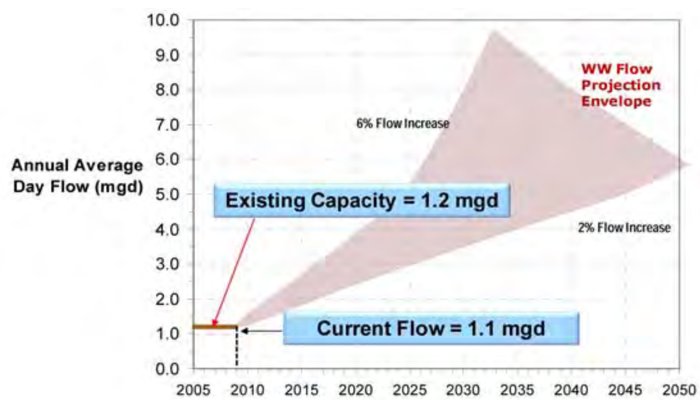
Available capacity at each facility was plotted on projected wastewater flow increase curves for each respective tributary area to determine the need for future capacity expansions based on current condition. As shown here, the existing Sundog WWTP is projected to provide adequate capacity until 2019 (based on a 2% wastewater flow increase rate). However, additional capacity is required at the Airport WRF now.



Sundog WWTP

Recommended Improvements

Several treatment technologies were considered for improving and expanding the Sundog WWTP and Airport WRF. The Modified Ludzack-Ettinger (MLE) and membrane bioreactor processes were selected for detailed economic and non-economic comparison. The MLE process is currently used at both of the existing facilities and is recommended for future improvements at each facility.



Airport WRF

Although the Sundog WWTP is not in need of an immediate expansion, the condition assessment identified several equipment rehabilitation and process enhancement needs. Near term improvements at the Sundog WWTP are, as follows:

- Replace the existing filters which have failed underdrains
- Temporary additional sludge dewatering equipment
- Enhancements to the nitrification/denitrification process
- Headworks Odor Control

<u>Near Term Improvements</u>

A new facility with an initial capacity of 3.75 mgd is recommended for the Airport WRF at an estimated capital improvement program cost of $41.6 million.

The estimated capital improvement program cost for the near term Sundog WWTP is $9.7 million.

Future Expansions

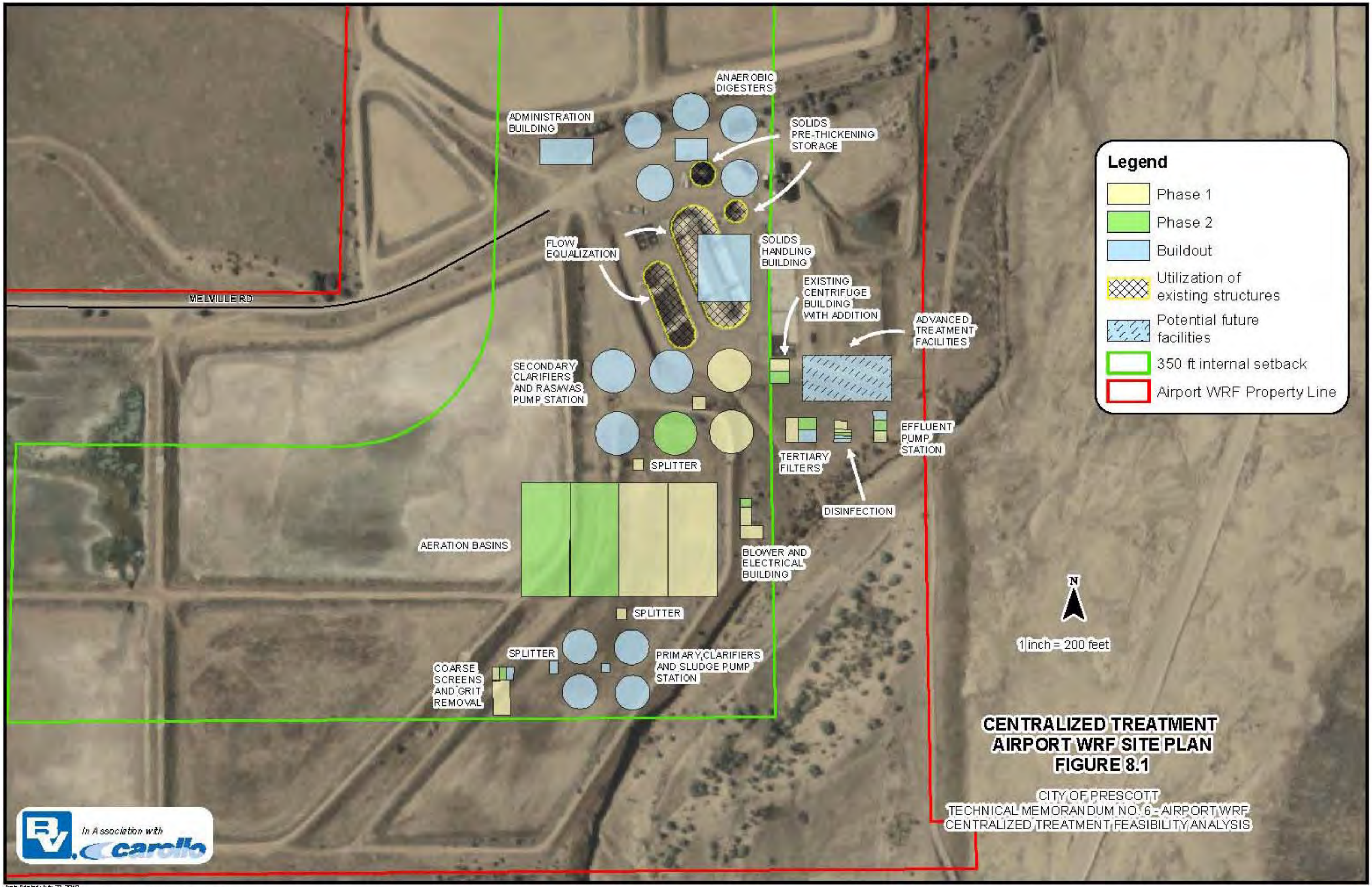
Two concepts were considered for future wastewater treatment:

- Maintain both of the existing treatment facilities
- Centralized treatment at the Airport WRF

The two concepts were developed and evaluated with a comparison of life cycle costs and non-economic criteria. The comparison indicated an advantage for centralized treatment at the Airport WRF, however the advantage was not great enough to make a strong recommendation. Therefore, it is recommended the City maintain treatment at both facilities at least until capacity at the existing Sundog WWTP runs out. Should the City decide to maintain the Sundog WWTP in the long term, a recommended phased expansion program is shown on the following page.

A build-out capacity for the Airport WRF of 15 mgd, represents the ultimate capacity for centralized treatment at the Airport WRF. A phased expansion program for a 15 mgd Airport WRF is shown on Page ES-9.


NEW HEADWORKS & SEPTAGE RECEIVING
CONVERT EXIST PRIMARY CLARIFIERS TO ANOXIC BASINS
CONVERT EXIST DITCHES TO AERATION BASINS
NEW DISK FILTRATION
NEW DISINFECTION
NEW GREASE RECEIVING
NEW DIGESTERS
RELOCATE FLARE
NEW WAS THICKENING
NEW DIGESTERS
NEW FLOW EQ BASINS
NEW SPLITTER BOX
NEW PRIMARY CLARIFIERS
NEW PS PUMP STATION
NEW BLOWER BUILDING
NEW AERATION BASINS
NEW SECONDARY CLARIFIERS
NEW SOLIDS DEWATERING BUILDING
POTENTIAL ADVANCED TREATMENT FACILITIES
Legend
Phase 1 (3.6 mgd)
Ultimate (5.4 mgd)
Potential ATF (5.4 mgd)
In Association with
carollo
CONVENTIONAL (MLE) TREATMENT ALTERNATIVE
FIGURE 5S.6
SUNDOG WWTP
CITY OF PRESCOTT
JUNE 2010


ANAEROBIC DIGESTERS
ADMINISTRATION BUILDING
SOLIDS PRE-THICKENING STORAGE
FLOW EQUALIZATION
SOLIDS HANDLING BUILDING
MELVILLE RD
EXISTING CENTRIFUGE BUILDING WITH ADDITION
ADVANCED TREATMENT FACILITIES
SECONDARY CLARIFIERS AND RAS/WAS PUMP STATION
EFFLUENT PUMP STATION
TERTIARY FILTERS
SPLITTER
DISINFECTION
AERATION BASINS
BLOWER AND ELECTRICAL BUILDING
SPLITTER
SPLITTER
PRIMARY CLARIFIERS AND SLUDGE PUMP STATION
COARSE SCREENS AND GRIT REMOVAL
Legend
Phase 1
Phase 2
Buildout
Utilization of existing structures
Potential future facilities
350 ft internal setback
Airport WRF Property Line
N
1 inch = 200 feet
CENTRALIZED TREATMENT
AIRPORT WRF SITE PLAN
FIGURE 8.1
CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 6 - AIRPORT WRF
CENTRALIZED TREATMENT FEASIBILITY ANALYSIS
In Association with carollo
Date Printed: July 27, 2010

Biosolids Management

Alternative solids treatment processes were considered for the Sundog WWTP and Airport WRF as well as alternatives for biosolids disposal. The recommended build-out approach for both facilities is anaerobic digestion to produce Class B biosolids, mechanical dewatering and land application.

EXECUTIVE SUMMARY OF TECHNICAL MEMORANDA

ES1 TM 1 – REGULATORY, COMPATIBILITY AND RELIABILITY REQUIREMENTS

ES1.1 Introduction

Existing and future regulatory requirements affect the planning and design of future treatment facilities at the Sundog WWTP and Airport WRF. An analysis of regulatory and reliability requirements was performed for aspects that included effluent quality, odor control, and process redundancy, as well as potential future regulatory requirements on emerging issues related to liquids treatment.

ES1.2 Existing Effluent Quality Requirements

Current discharge permit limits are summarized in Table ES1.2.

The City is currently reusing and/or recharging (depending on seasonal irrigation usage) all of its reclaimed water. If the City ever considers surface water discharge as an effluent disposal method, an AZPDES permit would be required, and the numerical standards associated with the surface water discharge regulations would need to be further evaluated.

Table ES1.2 Current Discharge Permit Limits Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements City of Prescott, Arizona		
Criteria	**Sundog WWTP [(1)]**	**Airport WRF [(2)]**
Flow, mgd		
Average monthly	6.0	2.2 [(3)]
Daily	Not established	Not established
Effluent Quality Classification	Class B+	Class B+
Total Nitrogen, mg/L		
Maximum limit [(4)]	10	10
Alert level	8	8
Turbidity, NTU	N.A.	N.A.
Fecal Coliform, cfu/100 mL		
Four of last seven samples	200	200
Single sample maximum	800	800

Notes:
(1) Amendment to Aquifer Protection Permit No. P-100353, LTF No. 22654, August 19, 2002.
(2) Amendment to Aquifer Protection Permit No. P-101733, LTF 46504, August 18, 2009.
(3) The infiltration basins at the Airport WRF are permitted for a maximum monthly average flow of 4.4 mgd, combined from both facilities.
(4) Based on a 5-month geometric mean of the results of the 5 most recent samples.

ES1.3 Water Quality Standards and Regulatory Requirements

Any significant major expansion at the Sundog WWTP and the Airport WRF will require compliance with ADEQ Best Available Demonstrated Technologies (BADCT) requirements. The technology assessment performed for this master plan considered technologies that are capable of achieving the minimum effluent water quality parameters specified per BADCT standards.

Table ES1.3 summarizes the different requirements for Class A+, B+, and C quality reclaimed water. It is important to note that BADCT disinfection requirements are essentially equivalent to the Class A+ quality requirements for new or expanded facilities with design flows above 250,000 gpd, such as the Sundog WWTP and the Airport WRF.

Table ES1.3 ADEQ Reclaimed Water Quality Standards
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

Parameter	Effluent Limits		
	Class A+ (1)	**Class B+ (2)**	**Class C (3)**
Secondary treatment	X	X	Stabilization ponds with 20-day detention
Filtration	X	NR	NR
Denitrification	X	X	NR
Disinfection	X	X	With or without
Total Nitrogen (as N) (4)	< 10 mg/L	< 10 mg/L	N/A
Turbidity			
Daily (24-hour) average	2 NTU	N/A	N/A
Single sample maximum	5 NTU	N/A	N/A
Fecal Coliform			
Single sample maximum	23 cfu/100 mL	800 cfu/100 mL	4,000 cfu/100 mL
Four out of last seven daily samples	None detect	200 cfu/100 mL	1,000 cfu/100 mL

Notes:
X = Requirement
NR = Not Requirement
(1) Reference: A.A.C. R-18-11-303
(2) Reference: A.A.C. R-18-11-305
(3) Reference: A.A.C. R-18-11-307
(4) Five sample geometric mean

Total trihalomethanes (TTHMs) are disinfection byproducts associated with the use of chlorine. There is no current numerical standard for TTHMs in Arizona for reuse, even though BADCT and Class A+ Reuse Rules both require minimization of TTHMs. For recharge, the A.A.C. requires that any water discharged to a drinking water aquifer must meet the drinking water quality standards. Therefore, a TTHM level of 80 µg/L (Stage 2 Disinfection / Disinfection By-Product Rules) applies to the recharge water.

Endocrine disruptors, pharmaceuticals, and personal care products are contaminants that could be regulated in the future. It is too early in the regulatory process to determine which contaminants may be regulated and to what level. However, the City should be aware of these contaminants and understand the impacts of possible future regulations.

Salt build-up in some areas of Arizona (such as the Phoenix metropolitan area) is a growing concern. Salt levels become more concentrated as water is used and reclaimed. Because the potential for reuse opportunities of reclaimed water diminishes (especially for irrigation uses) as salt concentrations rise, it is important to recognize the importance of controlling salt build-up in the future.

ES1.4 Odor and Noise Control

BADCT requirements establish that minimum setbacks must be maintained for water reclamation facilities. A setback of 1,000 feet should be maintained if no odor, noise or aesthetic controls are provided. A setback of 350 feet should be maintained if full noise, odor, and aesthetic controls are provided. These setbacks can be decreased if allowed by local ordinances, or if waivers are obtained from affected property owners.

Odor control measures will likely be required at both facilities per BADCT requirements. The majority of the odors originate from headworks, primary sedimentation, and solids handling processes, and special emphasis should be placed in providing odor control for those facilities in future plant expansions and improvements.

ES1.5 Reliability Requirements

Reliability and redundancy in the treatment process should be included in future designs, in order to provide the ability to comply with the required effluent quality goals even at times when process units are temporarily taken out of service for maintenance or repair.

ES2 TM 2 – CONTROL SYSTEM STANDARDS

ES2.1 Introduction

As part of the Sundog WWTP and Airport WRFs Capacity and Technology Master Plan, Black & Veatch was tasked with evaluating the City of Prescott Water SCADA system as designed for the Big Chino Pipeline Project and provide similar recommendations for implementation on the waste water system. However, the Big Chino Pipeline Project has not been constructed and the City of Prescott acknowledged that additional research into a standard control system was warranted.

Therefore, the original task was amended and B&V was asked to document a standard approach for design of control systems within the water treatment, wastewater treatment, distribution and collection systems such that equipment installed could be easily implemented into a future common SCADA system. A technical memorandum (TM-2 Control System Standards) would be prepared to document the resulting control system standards.

ES2.2 Recommended Control System Standards

Black & Veatch conducted a workshop at the City of Prescott to gather information regarding the specific requirements for future control systems and to determine the preferred control philosophies to be incorporated into the technical memorandum. Following is a summary of the control system discussions at the workshop and resulting standards included in TM-2.

- TM-2 should be a living document and should be updated as newer products become available and as additional City of Prescott standards are developed.
- A SCADA system software package has not been selected at this time.
- The City of Prescott staff had completed evaluations of various PLC manufacturers. Rockwell Automation Allen-Bradley (AB) is the preferred PLC manufacturer. TM-2 identifies the AB Logix control platform and RSLogix 5000 as the required programming software.
- Operator Interface Terminals (OIT), when necessary, should be AB Panelview Plus or Direct Automation and shall have Ethernet/IP communication.
- Control systems should be designed capable of Ethernet/IP communications to future SCADA system. Rockwell Automation Stratix Switch should be included in all PLC cabinets. An example network diagram is included in TM-2.
- Standard equipment control modes were established for Local, Auto, Remote, and SCADA as well as standard lights, alarms and status signals.

- Typical control philosophies and standard P&IDs for constant speed pumps, variable speed pumps, digital valve actuators and analog valve actuators are defined. These include typical monitoring, control and interlocks.
- Typical interface requirements for flowmeters, pressure transmitters and analog instruments in addition to typical P&IDs are included.

ES3S TM 3S – SUNDOG WWTP EXISTING CONDITIONS

ES3S.1 Introduction

The purpose of TM 3S is to gather, organize and document existing conditions for the Sundog WWTP, including available data, physical conditions of existing facilities, existing treatment capacity, and operational issues.

The Sundog WWTP is the City's largest wastewater treatment plant and currently receives the majority of the City's wastewater flow. The existing Sundog WWTP was last expanded in 1990, and designed for a treatment capacity of 6.0 mgd AADF. The liquid treatment process was upgraded to include primary clarification denitrification and filtration. The purpose of the process upgrade was to provide an effluent of suitable quality for irrigation of open-access turf sites and aquifer recharge by means of percolation recharge basins constructed near the Airport WRF under the same contract.

ES3S.2 Existing Information

Table ES3S.1 presents the hydraulic design criteria used for the most recent 1990 Sundog WWTP expansion.

**Table ES3S.1 Existing Hydraulic Design Flows
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona**

	1990 Design
Annual average daily flow, mgd	6.0
Maximum month average daily (design) flow, mgd	6.5
Maximum day flow, mgd	12.0
Hydraulic capacity, peak (hour), mgd	15.0

Table ES3S.2 presents the wastewater characteristics used for the most recent 1990 Sundog WWTP expansion.

Table ES3S.2	Design Wastewater Characteristics and Concentrations Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona	
	Average	**Maximum Month**
Characteristics	**mg/L**	**mg/L**
BOD_5	152	166
TSS	165	171
TKN	24	30
Temperature, °C		
Summer	25	
Winter	10	

The existing Sundog WWTP includes the following facilities:

- Headworks
  - Bar screens
  - Grit removal (vortex type)
- Primary Clarifiers
  - Conversion of existing final clarifiers
- Oxidation Ditches
  - Anoxic zones
  - Supplemental diffused aeration
  - Blower buildings
- New Circular Final Clarifiers
- Return Activated Sludge (RAS) Gravity fed to Screw Pumps
- Waste Activated Sludge (WAS) / Scum Pump Station
- Traveling Bridge Filter
- Chlorine Contact Basins
- WAS Thickening Anaerobic Digestion
- Belt Filter Press

The Sundog WWTP currently operates under Aquifer Protection Permit (APP) No. P-100353 which permits the plant for Class B+ effluent. Moving forward master planning will be based on technologies capable of producing Class A+ reclaimed water suitable for unrestricted reuse.

ES3S.3 Physical Conditions

The original coordinate system for the Sundog WWTP used the Arizona State Plane coordinate system.

The project benchmark was based on a brass cap set on USGS benchmark M-27 located on Oxidation Ditch 1 walkway. The project benchmark elevation was determined to be 5197.48 based on the City of Prescott Datum.

A geotechnical site investigation was performed in 1988 by Gellhaus Engineering and Testing Laboratories. Groundwater was not encountered in any of the test holes to the depths drilled.

The existing soil conditions are a mixture of sandy clay (SC) and gravelly clay (GC). Soft fill soils were encountered throughout the site. Overexcavation of the soft soils was required for the structure foundations.

A site walk was conducted on June 8, 2009 with the operation staff to assess the current condition of the existing Sundog WWTP equipment and structures. Inspections were limited to structure and equipment above or out of water. Major findings include:

- The headworks structure is in good condition. The influent screen and grit basin equipment exhibit some minor corrosion and wear on moving parts.
- The primary clarifier weirs show signs of corrosion and should be replaced. The primary sludge pumps are nearing the end of their life cycle and exhibit heavy corrosion.
- The area along the northeast corner of the oxidation ditches show signs of settlement as shown in Figure 3.1. The mounts for the brush rotors and gear box show significant concrete failure.
- The secondary clarifier basins appear to be in good structural condition. One of the clarifier drive mechanisms experienced issues with the gear box requiring replacement. The second clarifier drive mechanism is beginning to exhibit similar symptoms and may need replacement in the near future.
- The existing underdrains for the traveling bridge filters have failed and are in need of replacement. A full assessment of the current condition of the traveling bridge filters is located in TM7 Tertiary Filtration Evaluation.
- The existing chlorine contact concrete basin is in good condition. The UV disinfection equipment is in good condition with little sign of wear. No significant issues were located during the tour.

- Two gravity belt thickeners were originally installed in the Solids Processing Building. One of the units has been stripped of parts to maintain the other unit in operation.
- A single belt filter press is located in a prefabricated metal building adjacent to the Solids Processing Building. The building lacked appropriate ventilation and corrosion protection resulting in severe damage to the building structure. The belt filter press itself shows signs of corrosion and heavy equipment wear. The existing belt is misaligned creating operational issue. The belt and rollers have heavy struvite accumulations. Additionally, the unit shows significant signs of rotting and is at the end of its useful life. The unit will not continue to operate in the long term.

ES3S.4 Capacity Analysis

The Sundog WWTP was modeled to evaluate performance of the existing facilities under current loadings to determine current treatment capacity.

Current average annual flow and peak flow factors are presented in Table ES3S.3 based on historical plant data between January 2006 and April 2009.

Table ES3S.3 Current Hydraulic Evaluation Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Current Average Annual Flow (mgd)	2.58
Historical Hydraulic Peaking Factors	
Maximum Month : Average Day	2
Peak Day : Average Day	3.3
Peak Hour : Average Day	4.5

Influent wastewater characteristics were also determined from an analysis of plant historical records between 2006 and 2009. Influent wastewater characteristics used to establish existing Sundog WWTP treatment capacity are presented in Table ES3S.4.

Table ES3S.4	Current Wastewater Influent Loadings Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona				
Parameters	**Average (mg/L)**	**92%ile Max Month (mg/L)**	**92% Max Month: Average Annual Peak Factor**	**Summer Max Month Load (ppd)**	**Winter Max Month Load (ppd)**
BOD_5	390	608	1.56	2.58x608x8.34= 13,082	2.58x2x390x8.34= 16,783
TSS	418	676	1.62	2.58x676x8.34= 14,545	2.58x2x418x8.34= 17,988
TKN	39.5	57	1.39	2.58x57x8.34= 1,226	2.58x2x39.5x8.34= 1,700
NH3-N	31.5	48.8	1.52	2.58x48.8x8.34= 1,050	2.58x2x31.5x8.34= 1,356

Note: The winter peak load used for evaluation purposes is 30/38% higher than the maximum month load measured in 2006/2009. The reason for this anomaly is to account for the extremely high winter loads measured in 2006/2007.

A comparison of current existing wastewater flow and loading with the 1990 basis of design values is presented in Table ES3S.5. As shown the average influent flows are 43% of the 1990 design values. However, the average BOD and TSS mass loadings are approximately the same indicating a dramatic increase in wastewater strength.

A process model (BioWin^{TM}) was used to evaluate the treatment capacity of the Sundog WWTP.

The BioWin^{TM} model was configured to simulate the existing unit processes at the Sundog WWTP as summarized in Table ES3S.6. The BioWin^{TM} model schematic is shown in Figure ES3S.1.

Table ES3S.5	Influent Wastewater Concentrations Compared with 1990 Design Values Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona			
	Existing Conditions		**Current Conditions (1990)**	
	Average	**Max Month**	**Average**	**Max Month**
BOD_5 (mg/L)	373	608	152	166
TSS (mg/L)	402	676	165	171
TKN (mg/L)	39.5	57	N/A	N/A
NH_3-N (mg/L)	31.5	48.8	24	30

Table ES3S.6 Wastewater Treatment Process Units for Modeling Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona		
	Existing Process Equipment	
	Number	Parameters
Primary Clarifiers	2	Area = 4,350 ft^2 each SWD = 10ft
Oxidation Ditches	2	Volume = 175,000 ft^3 SWD = 11ft
Final Clarifiers	2	Diameter = 80ft SWD = 15ft
RAS Pumps	3 (2+1)	2,100 gpm each
WAS pumps	2	75 gpm
Tertiary Filters	2	65x15 ft each Dual media – anthracite/sand
Chlorine Contact Tank	2	44X30X8
Sludge Thickening	2 Gravity Belt Thickeners	100 gpm each
Anaerobic Digesters	2	50 ft diameter, SWD – 25ft Volume – 49,000 ft^3 each
Belt Filter Press	1	2 m width

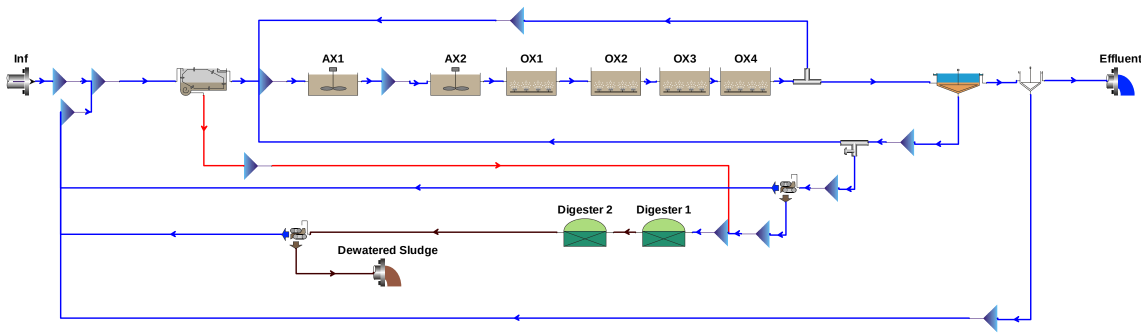


Figure ES3S.1 Sundog WWTP BioWin™ Model Configuration Schematic

The Sundog WWTP BioWin™ model was calibrated to match predicted values with the actual reported average annual and maximum month values of effluent ammonia, nitrate and nitrite concentration, volatile fraction of the MLSS, solids production in the waste activated sludge (WAS) stream, and digested solids production. The calibrated model predictions are in relatively good agreement with the plant data for average annual and maximum month conditions.

Overall plant capacity was determined considering the individual firm capacity of each individual unit process. The evaluation criteria of the individual unit processes are summarized in Table ES3S.7.

Table ES3S.7 Wastewater Treatment Process Units Evaluation Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Process Equipment Evaluation Criteria		
		Criteria	**Commentary**
Headworks	-	Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows.
Primary Clarifiers	-	Influent Flow	Maximum rated capacity was compared to peak daily or peak hourly flows
Tertiary Filters	- -	Hydraulic peak flows Secondary effluent turbidity	Maximum rated capacity was compared to peak daily or peak hourly flows
Chlorine Contact Tank	-	Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows
Belt Filter Press	-	Digester Efficiency	Maximum rated capacity was compared to peak weekly solids production
Oxidation Ditches Final Clarifiers RAS Pumps WAS pumps Sludge Thickening Anaerobic Digesters	- - - - -	Influent flow Influent loads Solids retention Time (SRT) Mixed Liquor Suspended Solids (MLSS)	BioWin™ Model

All unit processes were analyzed against the individual process evaluation criteria. Figure ES3S.2 presents the results of the capacity analysis. As shown, the secondary treatment process, filters and solids treatment/processing are limiting the existing plant capacity to 3.0 mgd compared to the 1990 upgrade project design capacity of 6.0 mgd. The difference is due to the drastic increase in wastewater strength over the last 20 years, most likely due to reduced water use and appliance efficiencies.

As part of the capacity analysis, a field investigation was conducted to assess periodic operating challenges to achieve complete denitrification.

The investigation consisted of DO and temperature profiling in addition to physical observations. In general, the major findings of the field investigation included identification of a flow split imbalance between ditch 1 and 2, the need for improved DO control and the need for testing the process response to polyaluminum chloride addition.

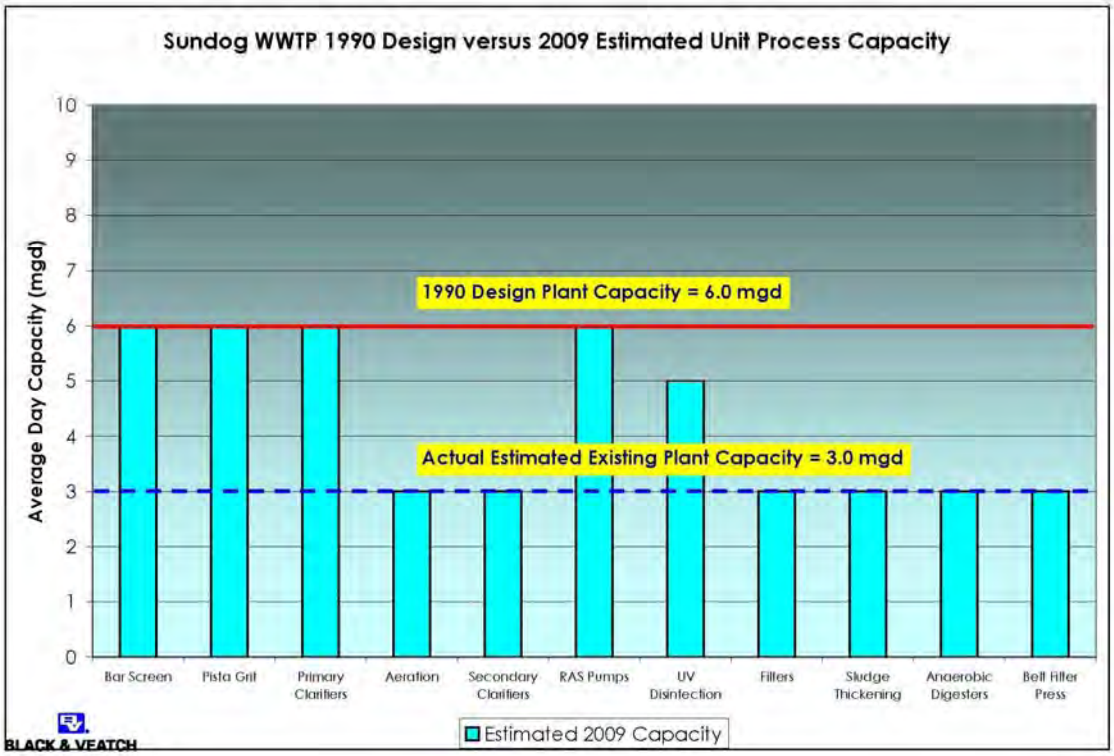


Figure ES3S.2 Sundog WWTP 1990 Design versus 2009 Estimated Unit Process Capacity

ES3S.5 Plant Issues, Needs and Operational Preferences

Based on the condition assessment, capacity evaluation and discussions with plant staff; several recommendations for each unit process were identified, as presented in Table ES3S.8.

Table ES3S.8 Unit Process Recommendations
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Unit Process	Recommendations
Headworks	• New Headworks facility to be coordinated with new Sundog Trunk Main. • Parshall flume sized for peak wet weather events equipped with ultrasonic level detector programmed for entire range of influent flows. • Redundant influent screens. • Screening washer/compactor to decrease operations and reduce odor and vector issues. • Multiple smaller vortex grit basins to handle the wide range of influent flows. • Integrated septage receiving station.
Primary Clarifiers	• Install sludge blanket level detectors for process control and procure hand held devices. • Filter the scum and meter to the anaerobic digesters in lieu of disposal to the drying bed.
Settled Sewage PS	• Install a check valve to prevent overflows to filtrate manholes.
Oxidation Ditches and Aeration Blowers	• Automated DO control for the aeration system to provide better process control and reduce filamentous growth. • Mechanical mixing to improve mixing within the anoxic zones. • Chlorine spray system to control surface foam in the oxidation ditches. • Chlorination of the RAS line. • Install launder or V-notch weirs in flow splitter. • Install VFDs on all brush rotors. • Install DO probes, 4 per ditch. • Install PLC for DO control. • Install submersible mixers.
Secondary Clarifiers	• Install sludge blanket level detector for process control. • Provide launder covers to reduce algae growth.

Table ES3S.8 Unit Process Recommendations Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona	
Unit Process	**Recommendations**
Tertiary Filters	• The existing traveling bridge filters have experienced failure of the underdrains and require rebuilding or replacement.
Disinfection	• Automated flow pacing and transmissivity control. • Install wiper system to maintain efficiency and improve lamp life. • Adjust effluent gate control to reduce cycling • Cover basins to reduce algae growth and prevent dust intrusion.
Solids Processing	• Rebuild the second GBT to provide redundancy. • Additional digester volume to meet the required 15 day HRT for Class B. • Digested sludge storage for 5 days per week sludge dewatering operations. • New dewatering equipment and facility.

In addition to the above unit process recommendations and the need for additional treatment capacity, the following additional plant components are recommended:

- New septage receiving facility.
- A grease receiving station.
- Stormwater flow equalization.
- Supervisory Control and Data Acquisition (SCADA) system for monitoring and control of plant process.

ES3A TM 3A – AIRPORT WRF EXISTING CONDITIONS

ES3A.1 Introduction

The purpose of this technical memorandum is to gather, organize, and document existing conditions for the Airport WRF, including available data, physical condition of existing facilities, existing treatment capacity, and operational issues. This memorandum serves as the foundation for defining and developing the design for the required near-term improvements at the Airport WRF. It also serves as the existing condition reference point for long-term treatment technologies and capacity assessments.

The original Airport WRF was constructed in 1978, and designed for a treatment capacity of 0.75 million gallons per day (mgd) Annual Average Daily Flow (AADF). The Airport WRF expansion project in 1998 was constructed for a treatment capacity of 2.25 mgd AADF, and included upgrades for denitrification and tertiary filtration. The purpose of the 1998 process upgrade was to continue to provide an effluent of suitable quality for golf course irrigation and aquifer recharge by means of existing recharge basins. The current Aquifer Protection Permit (APP) for the Airport WRF is based on an AADF of 2.2 mgd.

ES3A.2 Existing Information

Table ES3A.4 shows that the 1998 expansion design considered that the hydraulic capacity of the water reclamation facility would be increased in the future to accommodate the previously projected buildout flows.

Table ES3A.4 Previous Design Flows
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

	1998 Design	Buildout per 1998 Design
Annual average daily flow, mgd (average flow at start-up)	2.25 (0.65-0.75)	2.4
Maximum month average daily (design) flow, mgd	2.7	2.9
Maximum day flow, mgd	4.2	4.8
Hydraulic capacity, peak (hour), mgd	6.3	7.2
Minimum flow, mgd	0.8	0.8

Table ES3A.5 shows the wastewater characteristics used in the 1998 expansion design. The concentrations shown in Table ES3A.5 were based on plant records for 1992 and 1993 and additional influent sampling conducted in September 1995.

Table ES3A.5 Previous Design Wastewater Characteristics and Concentrations
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Characteristics	Average		Maximum Month		Load Peaking Factor
	mg/L	ppd	mg/L	ppd	
BOD_5	117	2,340	155	3,750	1.6
TSS	159	3,190	211	5,103	1.6
TKN	35	697	36	871	1.25
Temperature, °C					
Summer	25				
Winter	12				

The previous (1998) improvements to the Airport WRF consisted of the following facilities:

- Headworks: mechanical bar screen with manual screen bypass, parshall flume, and grit removal settling basin with grit screw.
- Oxidation ditches: anoxic basins, new oxidation ditch, and modifications to existing ditch
- Secondary clarifier and sludge pump station
- Traveling bridge filter
- UV Disinfection

Additional improvements in 2008 included modifications and upgrades to the following facilities:

- Sludge holding tank
- Solids handling (centrifuge) building

ES3A.3 Physical Conditions

A visual inspection of the major equipment and structures at the Airport WRF was conducted as part of this project. The intent of the inspection was to document the general condition of all major equipment and structures at the plant, to provide input for future improvements planning. The visual condition assessment of the major equipment and structures at the plant is summarized in Table ES3A.6. In general, most of the facilities at the Airport WRF can be considered in relatively good condition, with a few unit processes needing attention to resolve minor issues.

Table ES3A.6 Condition Assessment of Existing Facilities Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona		
Unit Process	**Structure Condition**	**Equipment Condition**
Headworks		
Mechanical bar screen	Good	Good
Manual bar screen	Good	Good
Grit removal	Good	Good
Activated Sludge System		
Anoxic basins	Good	Good
Oxidation Ditch No. 1 (1998)	Good	Good
Oxidation Ditch No. 2 (1976)	Fair (1)	Fair (1)
Secondary clarifier	Good	Good
Tertiary filter	Good	Good (2)
UV Disinfection	Good	Good
Effluent and NPW Pumping		
Pump station / Wet well	Good	Good
Recovery Well Pump Station	Good	Good
Solids Handling		
Solids Holding Tank	Fair (3)	Good
Dewatering system	Good	Good

Notes:
(1) Minor cracks and concrete spalling were observed. The shotcrete thickness is 2.5 inches per the record drawings. Brush rotors showed some evidence of corrosion, and a few missing blades. Plant staff has recently performed maintenance on the equipment and equipment is in operation.
(2) Media replacement was performed in 2007. Plant staff reported that the filter underdrain system was in good condition at the time that the media was replaced.
(3) Minor cracks and concrete spalling were observed.

ES3A.4 Capacity Analysis

The capacity of existing facilities at the Airport WRF was estimated based on a detailed evaluation of the performance of each unit process using existing flow and loading conditions. Recent (2006 – 2009) plant operating data was used to establish existing hydraulic and loading criteria. The capacity of the Airport WRF was estimated using typical performance criteria and detailed process modeling.

Daily average, high, and low influent flows were obtained from plant operational data records between January 2006 and April 2009. The average daily flow into the plant has been consistently increasing over time. Throughout a calendar year, the plant typically receives higher flows during winter months, probably due to infiltration during wet weather months. The recommended design hydraulic peaking factors based on the plant data analyzed are presented in Table ES3A.7. The recommended peaking factors are similar to values observed in other typical domestic wastewater treatment facilities in Arizona.

Table ES3A.7 Design Hydraulic Peaking Factors
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Hydraulic Peaking Factor (1)	Value
Maximum Month Average Day	1.4
Peak Day	2.0
Peak Hour	3.0

Note:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

The wastewater characteristics for the plant capacity analysis were determined based on an analysis of the plant's historical wastewater quality records. Influent characteristics were obtained from plant operations historical records between 2006 and 2009.

Table ES3A.8 presents the wastewater characteristics at average and maximum month conditions, used for the capacity evaluation presented herein. Average and maximum month concentrations were based on a statistical analysis over the entire analysis period (2006 to 2009).

Table ES3A.8 Design Wastewater Concentrations
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott

Parameter	Unit	Annual Average Day (1)	Maximum Month Average Day (2)
Design Concentrations			
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity (3)	mg/L	250	250
Temperature (4)	°C	18.4	12.4
pH	--	7.3	7.3

Notes:
(1) Average wastewater concentrations were calculated over the analysis period (2006 to 2009).
(2) Based on the observation that the maximum month load (ppd) coincides with the maximum month flow (mgd).
(3) Assumed. No data available.
(4) Based on mixed liquor temperature measurements.

The existing wastewater concentrations are significantly higher than the criteria used for the design of the secondary treatment facilities in the 1998 expansion. The existing BOD and TSS wastewater concentrations are higher than the original design criteria values by factors ranging between 2.6 and 3.2. The existing average TKN concentrations are similar to the values used for the original design.

Additional sampling upstream of the WRF was performed by the City, in order to identify any possible sources of unusually high loadings (see TM 3A – Appendix C for sampling locations and results). Wastewater samples were collected at several points in the collection system in the vicinity of the Airport WRF. BOD and TSS values at the plant headworks agreed with recent elevated values.

The capacity of each process unit was evaluated by comparing its maximum capacity to the appropriate governing criterion. The estimated capacity was expressed in terms of average day flow using the appropriate peaking factors depending on the governing criterion particular for each unit process.

Figure ES3A.1 summarizes the capacity analysis estimate for the existing facilities at the Airport WRF. The current tertiary treatment facilities (filter and UV disinfection) limit the plant capacity at an average day flow capacity of 1.2 mgd. The current secondary treatment system has a capacity of 1.5 mgd mainly due to limitations in secondary clarification capacity.

ES3A.5 Operational Considerations

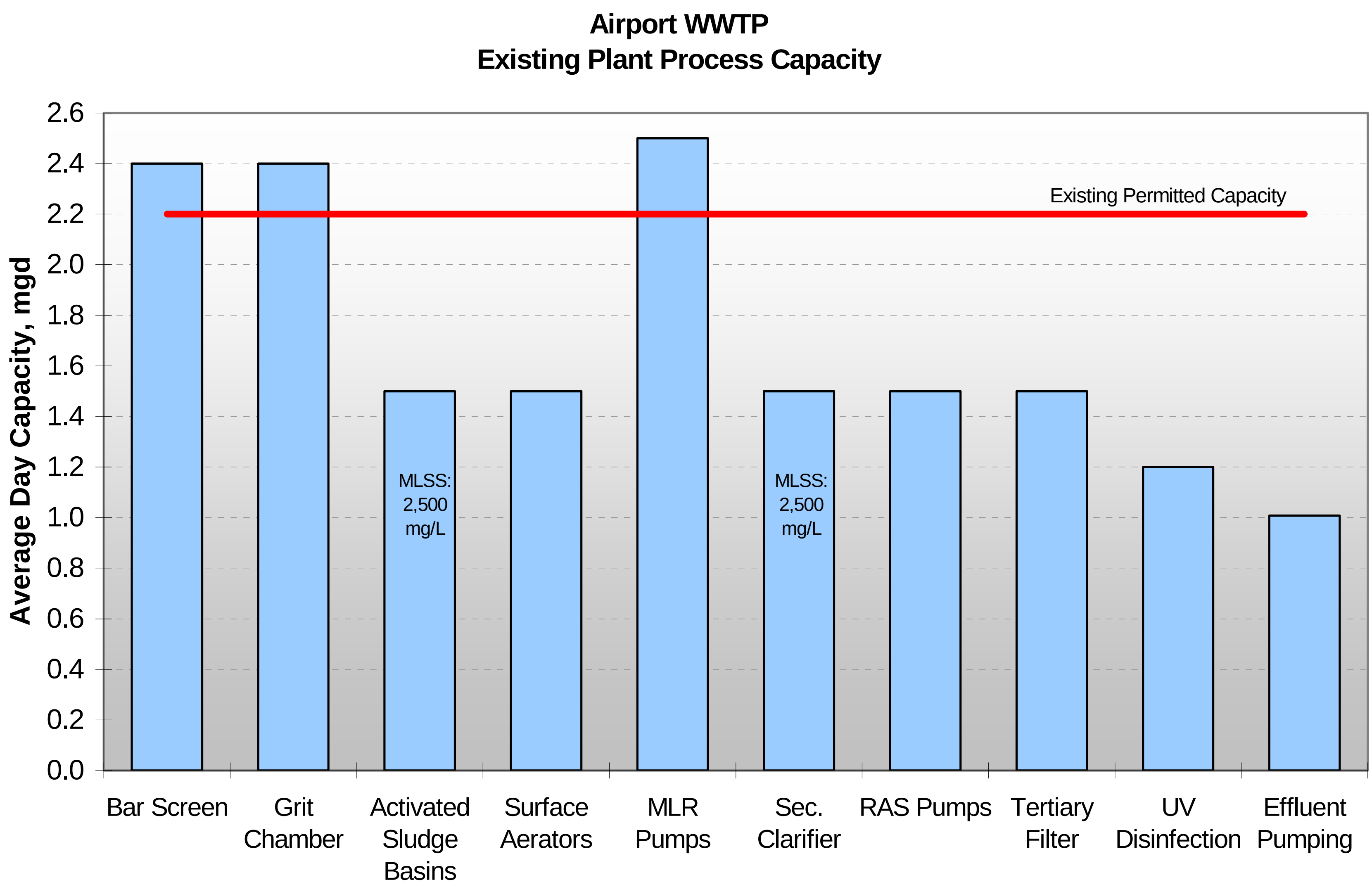
The screening equipment is currently operating without any major concerns. The grit removal equipment is in good working condition, other than a few minor mechanical repairs that have been required.

The plant had been operating with only the newer oxidation ditch basin (Oxidation Ditch No. 1) in service. The original oxidation ditch basin (Oxidation Ditch No. 2) was being used as an emergency equalization basin. Due to increased loadings in the plant influent, plant staff started operating Oxidation Ditch No. 2 at the end of 2008, in order to increase the aerobic solids retention time and improve the system operation, especially under winter conditions.

There is currently only one secondary sedimentation basin in operation. While the equipment is operating properly, there is no redundancy in the secondary clarification process. More clarification capacity is required not only to increase plant capacity, but also to provide redundancy. However, addition of secondary clarifier capacity needs to be evaluated within the context of the overall site master plan.

There is currently no redundancy in the filtration facilities. Specific recommendations regarding tertiary filtration are addressed in Technical Memorandum No. 7.

The plant does not currently have any type of SCADA monitoring or control system available. At the minimum, monitoring of key processes and alarms notifications are desirable in the short-term. Monitoring and alarms would improve the reliability of the system, providing operators the ability to identify major upsets during unattended operation periods. In the long-term, instrumentation and control elements could be incorporated in a plant control system for automation of the major processes, such as secondary process equipment. Automation of major processes will optimize energy consumption, and provide a more reliable operation of the treatment process.



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SUMMARY OF CAPACITY ANALYSIS ESTIMATE

FIGURE ES3A.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

ES4 TM 4 – INFLUENT AND EFFLUENT MANAGEMENT

ES4.1 Introduction

The main objectives of this technical memorandum (TM) are to (1) address the relative effectiveness of infiltration/inflow (I/I) reduction in the collection system versus the extent of treatment plant expansions to accommodate increased flows due to I/I, and (2) address issues related to existing and future effluent management.

ES4.2 Influent Management

Site master planning at the City's wastewater treatment facilities requires the establishment of design flow peaking factors for the purpose of unit process sizing. The peak hour flows recently observed at the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF) exceed typical peaking factor values of 2 to 3 observed in other communities of similar size.

The City of Prescott Wastewater Collection System Model Study (Carollo, January 2008) identified significant amounts of I/I entering the wastewater collection system as a result of storm events. Based on 2004-2005 information, approximately 25-28 percent of the annual flow received at the Sundog WWTP appears to be I/I, and the I/I contribution to the Airport WRF annual flow is approximately 9-13 percent.

A detailed analysis of influent flow records at the Sundog WWTP and the Airport WRF was performed in order to quantify the immediate flow equalization needs at both facilities. Both facilities experienced significant peak flows during storm events in January 2010. The analysis of Sundog WWTP influent flows is presented in Figure ES4.1. The analysis of the Airport WRF influent flows is presented in Figure ES4.2.

The proposed strategy for handling storm flows at the Sundog WWTP is to plan influent flow equalization facilities for the short and medium term using new tankage for a recommended volume of 9 million gallons (MG). While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the recommended volume includes a reasonable safety factor of 1.2 (industry standard) over the equalization volume of 7.6 MG estimated based on the 2010 storm event.

The proposed strategy for handling storm flows at the Airport WRF is to plan influent flow equalization facilities for the short and medium term using the existing oxidation ditch basins. The existing oxidation ditches will not be utilized for secondary treatment in the Airport WRF Phase 1 capacity improvements, and they will become available for flow equalization when the new Phase 1 aeration basins are completed. The total available volume of the two existing oxidation ditch basins (1.57 MG) provides a safety factor of 2.2

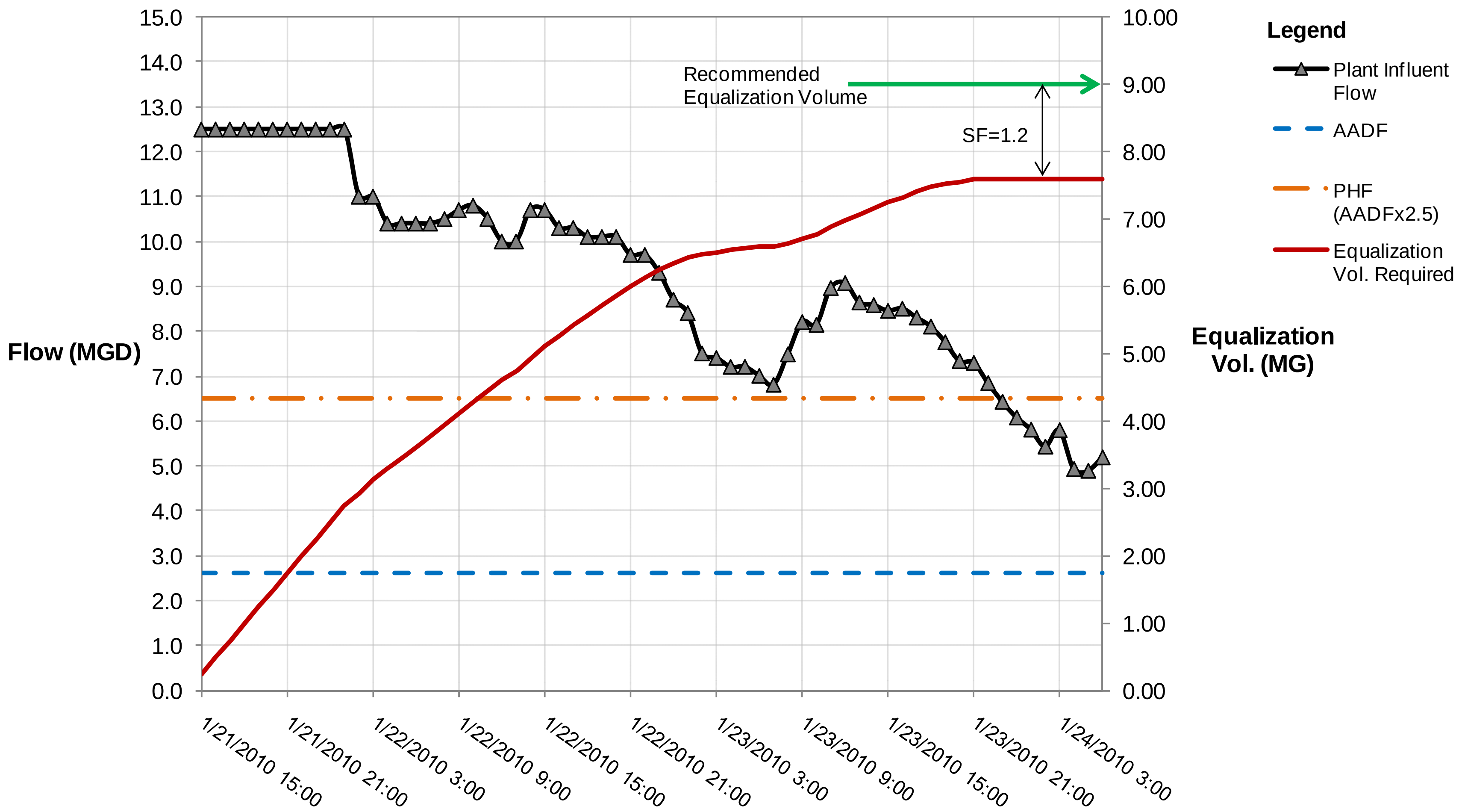
over the equalization volume of 0.7 MG estimated based on the 2010 storm event. While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the existing total oxidation ditch volume provides a reasonable safety factor over the calculated required volume.

ES4.3 Effluent Management

In support of the safe yield goal and based on the City's "Water Management Policy" (adopted October 2005), the City utilizes 100 percent of the effluent from its two treatment facilities, including a portion for reuse (golf course irrigation, commercial, and other) and the remaining amount for groundwater recharge. During 2010 about 67% of the recharge water was from Sundog WWTP and 33% was from Airport WRF. About 72% of the treated effluent was recharged and 28% was used for otherwise.

The City's existing recharge facility at the Airport WRF site is permitted for 4.4 mgd (annual average) and the City has contract commitments for approximately 2.0 mgd (annual average) of effluent to outside customers. With existing total effluent flows (Sundog WWTP and Airport WRF) at approximately 3.7 mgd, the City has available capacity to continue reclaiming 100 percent of their effluent in the short term. However, it is important for the City to develop a reclaimed water master plan to accommodate future increased effluent flows.

The recommended reclaimed water master plan should comprehensively address both physical and administrative aspects of effluent management. Two major factors that contribute to the need for the reclaimed water master plan are: 1) The proposed Phase 1 expansion of the Airport WRF to 3.75 mgd will require documentation of compatible effluent management facilities; and 2) The reclaimed water master plan will have to address issues such as annual water balance, given the potential seasonal variations of effluent reuse through outside contracts. Although the City may have contract commitments to provide effluent for irrigation, it may be the City's responsibility to provide "backup" effluent disposal for seasonal and/or wet weather conditions.



SUNDOG WWTP FLOW EQUALIZATION ANALYSIS

FIGURE ES4.1

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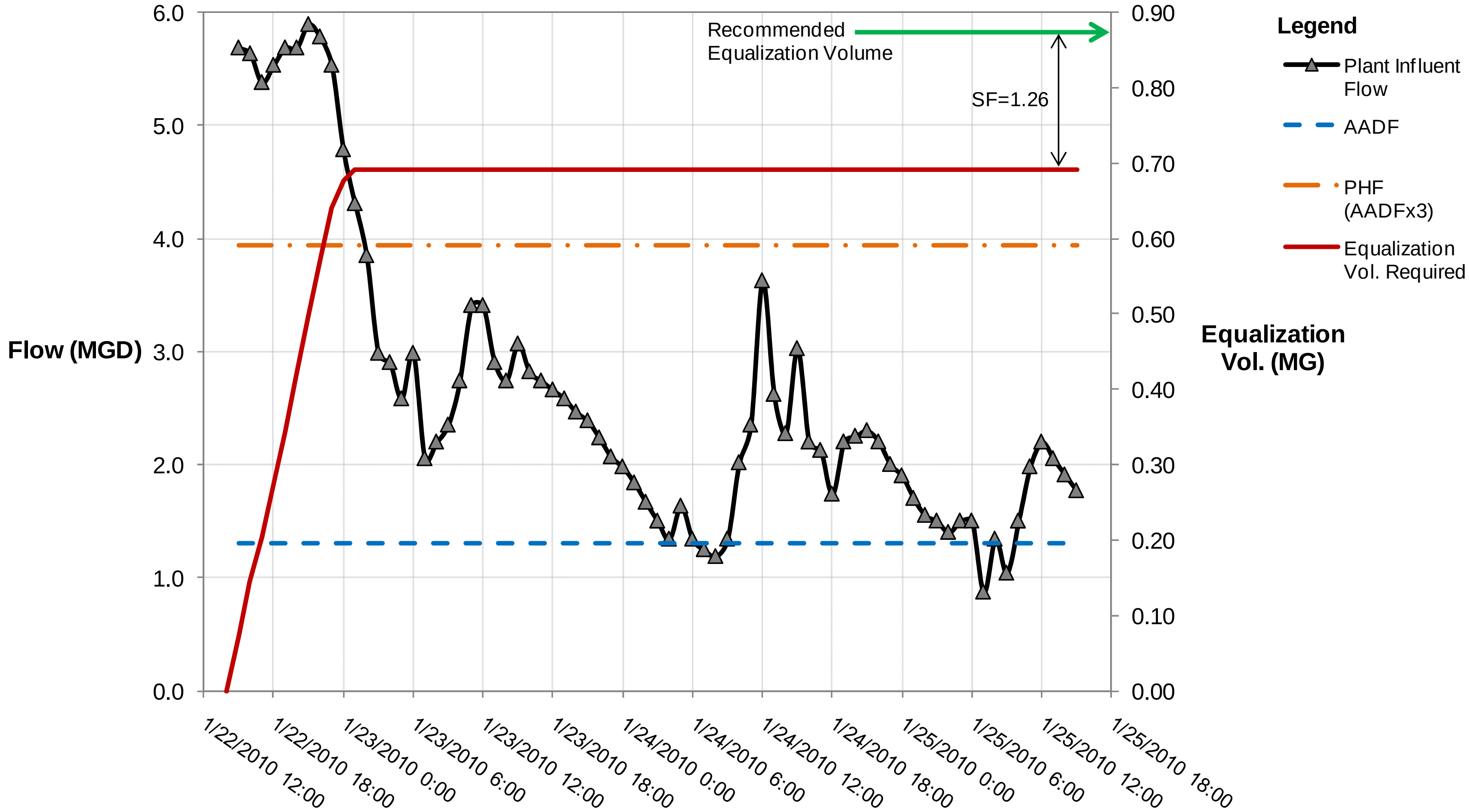
CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT



AIRPORT WRF FLOW EQUALIZATION ANALYSIS

FIGURE ES4.2

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CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT

ES5S TM 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES

ES5S.1 Introduction

The purpose of TM5S is to identify potential treatment technologies for upgrading and expanding the Sundog WWTP, compare those technologies in order to screen the options, and perform detailed analyses of the short listed options to identify the preferred treatment alternative.

ES5S.2 Planning Conditions

Wastewater flow projections for the Sundog WWTP were developed in an effort to estimate the timing of the expansions required at the facility. Flow projections were formed around both aggressive and conservative growth scenarios to develop a range of possible flow increase curves that bracket the required timing for plant capacity expansions. Existing plant capacity was established in TM 3S.

Figure ES5S.1 and Figure ES5S.2 presents the flow increase curves for the City of Prescott Sundog W WTP and the Airport WRF. The aggressive flow increase scenario (Scenario A) is based on actual fast growth period in the City of Prescott, and was developed using historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. The conservative flow increase scenario (Scenario B = 2% annual increase) represents a moderate growth scenario, and is based on growth estimates in the several planning documents for the City of Prescott.

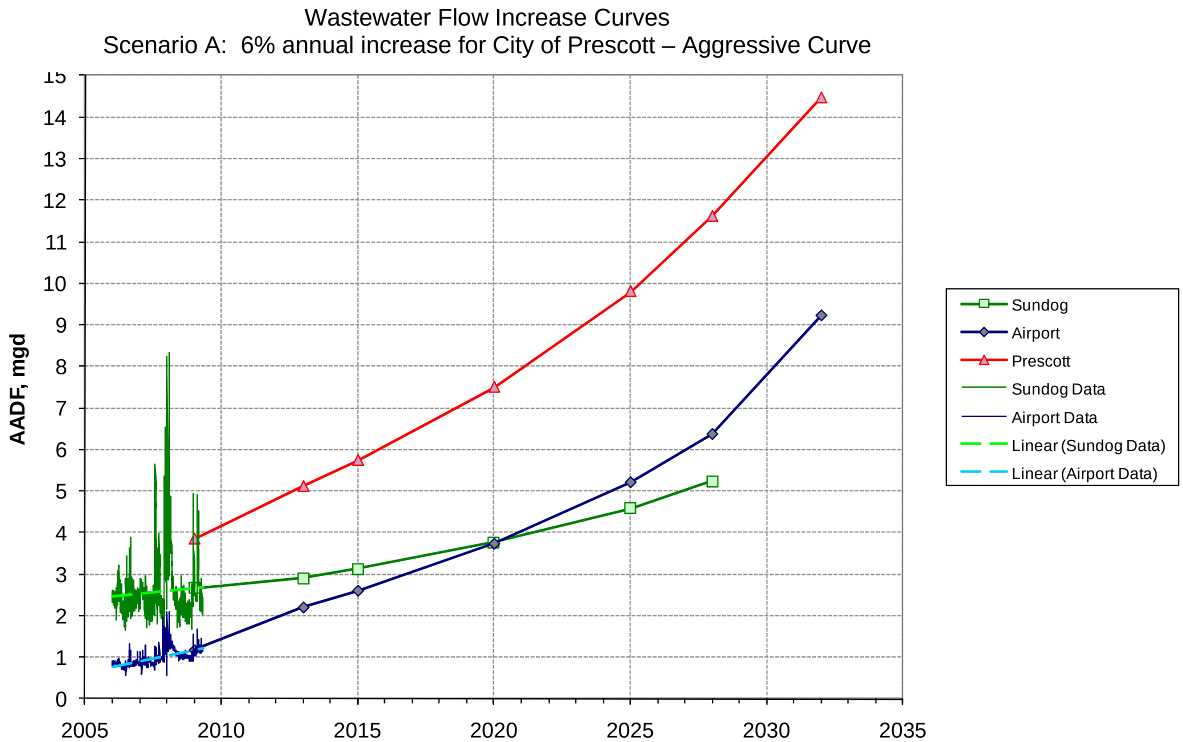


Figure ES5S.1

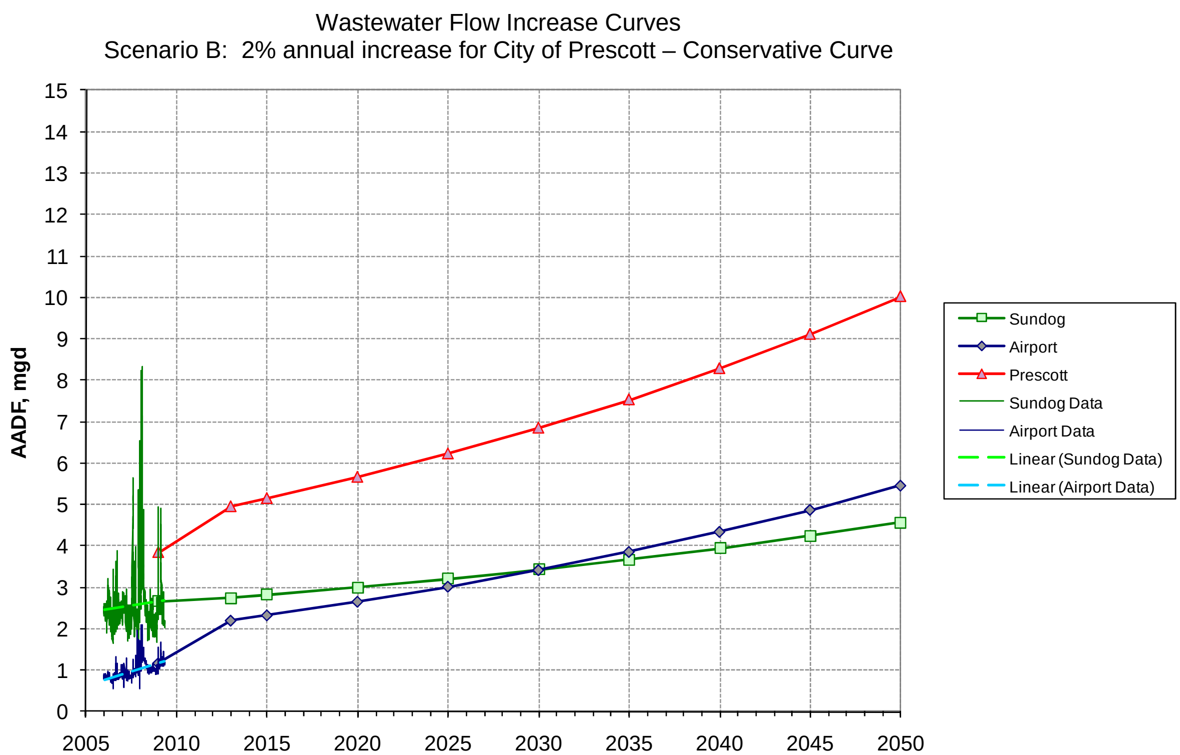


Figure ES5S.2

ES5S.3 Phasing

The build-out annual average day flow (AADF) for the Sundog WRF tributary area is 5.3 mgd based on the City of Prescott Wastewater Master Plan. For the purposes of this technology assessment and site master planning project, the build-out capacity was established at 5.4 mgd.

The capacity for each treatment train of the master planned capacity has been established at three treatment trains of 1.8 mgd. This capacity was established based on discussions with the City in several workshops, and addresses the City's need for additional treatment capacity beyond the existing plant capacity of 3.0 mgd. The first phase capacity of 3.6 mgd is more cost-effective than a four treatment train alternative and also provides a reasonable timeframe before the next capacity expansion is required.

Figure ES5S.3 shows the expected timing associated with the existing capacity, and with a first phase of improvements to achieve a treatment capacity of 3.6 mgd. It is estimated that the plant will reach its existing capacity between the years 2014 and 2020. It is also estimated that with a Phase 1 capacity of 3.6 mgd, the Sundog WWTP would require the next expansion phase to be in service as early as the year 2019 and as late as the year 2034.

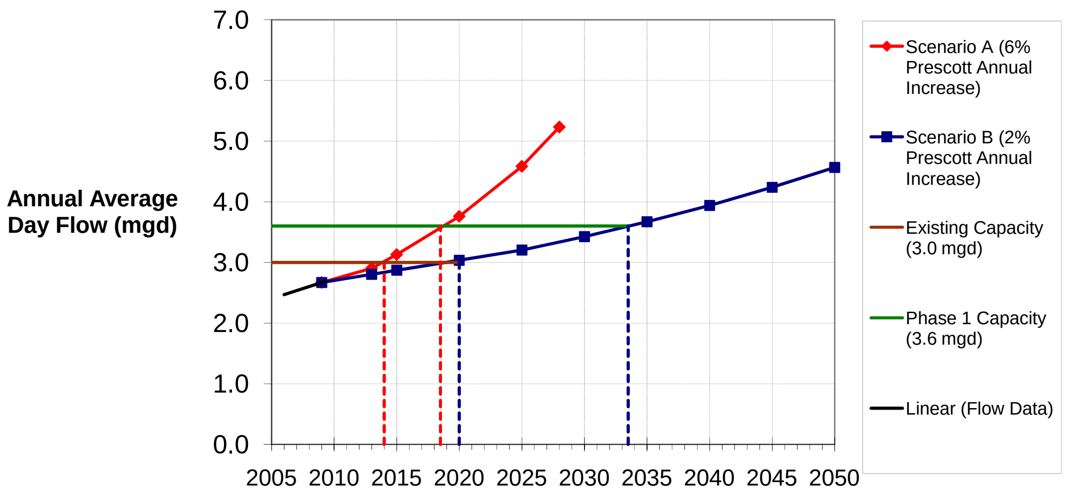


Figure ES5S.3

ES5S.4 Alternatives Analysis/Selection

For the initial evaluation of process alternatives, a full range of twelve treatment options were considered for completeness. While existing process technologies at the plant was not a requirement of the master plan, there are significant advantages to the City with maintaining a familiar process. The full range of treatment alternatives were reviewed and discussed in project workshops with the City. There was a project team consensus that two alternatives should be brought forward for detailed evaluation at both plants:

- Alternative 1 – conventional activated sludge with Modified Ludzack-Ettinger Process (MLE) for biological nitrification and denitrification
- Alternative 2 – Membrane Bioreactor (MBR) with MLE for biological nitrification and denitrification

Detailed analyses of the required components and sizes for each technology were performed in order to develop costs for both capital improvements and O&M. The resulting cost comparison is summarized in Table ES5S.1 below.

Table ES5S.1 Alternatives Detailed Cost Comparison (Ultimate)
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Cost Type	Alternative 1 MLE	Alternative 2 MBR
Total Probable Construction Cost	$ 75,131,000	$ 74,963,000
Total Probable Present Worth O&M Cost	$ 35,614,000	$ 44,889,000
Total Probable Present Worth Cost	$ 110,745,000	$ 119,852,000

Additionally, a non-economic comparison of alternatives was performed to finalize the process selection. Table ES5S.2 summarizes the results of the non-economic evaluation.

Table ES5S.2 Non-Economic Factor Comparison
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

	Weighting Factor	Alternative 1 - Conventional MLE		Alternative 2 - MBR	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
I&C Intensity	x 3	8	24	4	12
Compatibility w/AOP's	x 2	5	10	8	16
Sustainability Reuse	x 3	6	18	8	24
TOTAL			156		150

Note:
1. Comparison of non-economic factors where 10 = best and 1 = worst

The costs and non-economic factors associated with MLE versus MBR treatment alternatives were presented and reviewed with City staff during project workshops. Based on the evaluation results and detailed discussions among project team members, MLE is the preferred treatment alternative for future expansions and improvements at the Sundog WWTP. Primary reasons for this recommendation include the following:

- MLE has a comparable capital cost and lower energy and O&M costs compared with MBR.
- MLE is consistent with the current treatment technology and is less complex than MBR.
- There is currently no water quality requirement for MBR treatment and MLE treatment does not preclude future advanced treatment facilities for emerging contaminants.
- MLE retains the ability to meet MBR effluent quality with the addition of advanced filtration facilities.

ES5A TM 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES

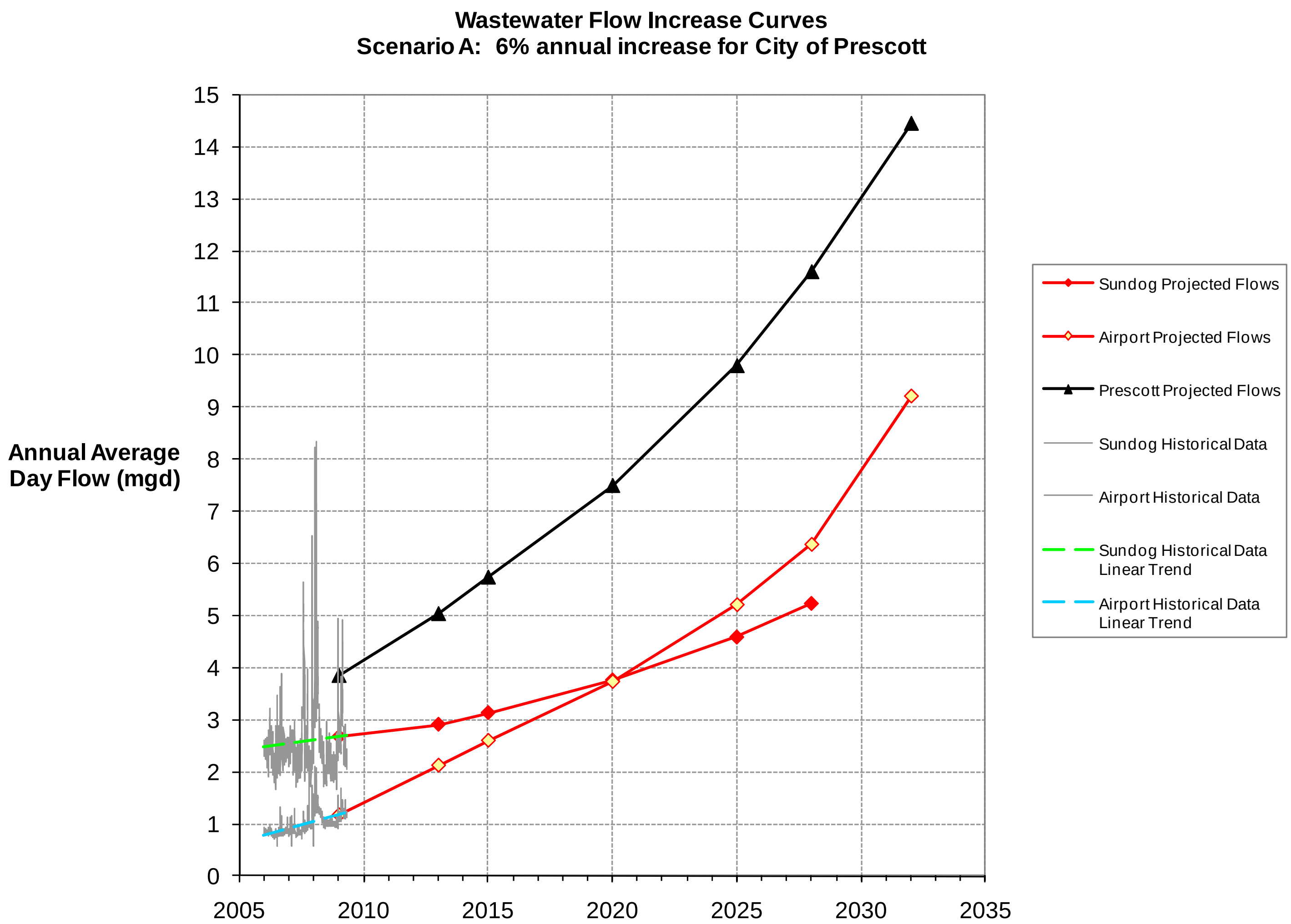
ES5A.1 Introduction

The purpose of this technical memorandum is to develop and evaluate treatment technology alternatives for the Airport WRF. The alternatives evaluation is based on a two-step approach. First, an initial screening of alternatives is carried out in order to identify the alternatives that are carried forward for detailed evaluation. Second, a detailed evaluation is performed based on a comparison of life-cycle costs and other non-economic factors. Site layouts and the costs associated with each treatment alternative for the projected Phase 1 and buildout conditions are presented for the Airport WRF.

ES5A.2 Planning Conditions

Wastewater flow projections for the Airport WRF were developed in an effort to estimate the timing of the expansions required at the facility. The approach to develop the flow projections was to establish aggressive and conservative flow increase scenarios in order to develop a range of possible flow increase curves that bracket the required timing for plant capacity expansions. Existing plant capacity was established in TM 3A.

Figure ES5A.1 and present the flow increase curves for the City of Prescott, the Sundog WWTP, and the Airport WRF. The aggressive flow increase scenario (Scenario A) is based on actual fast growth period in the City of Prescott, and was developed using historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. The conservative flow increase scenario (Scenario B) represents a conservative growth scenario, and is based on growth estimates in the several planning documents for the City of Prescott.



FLOW INCREASE CURVES – SCENARIO A (AGGRESSIVE)

FIGURE ES5A.1

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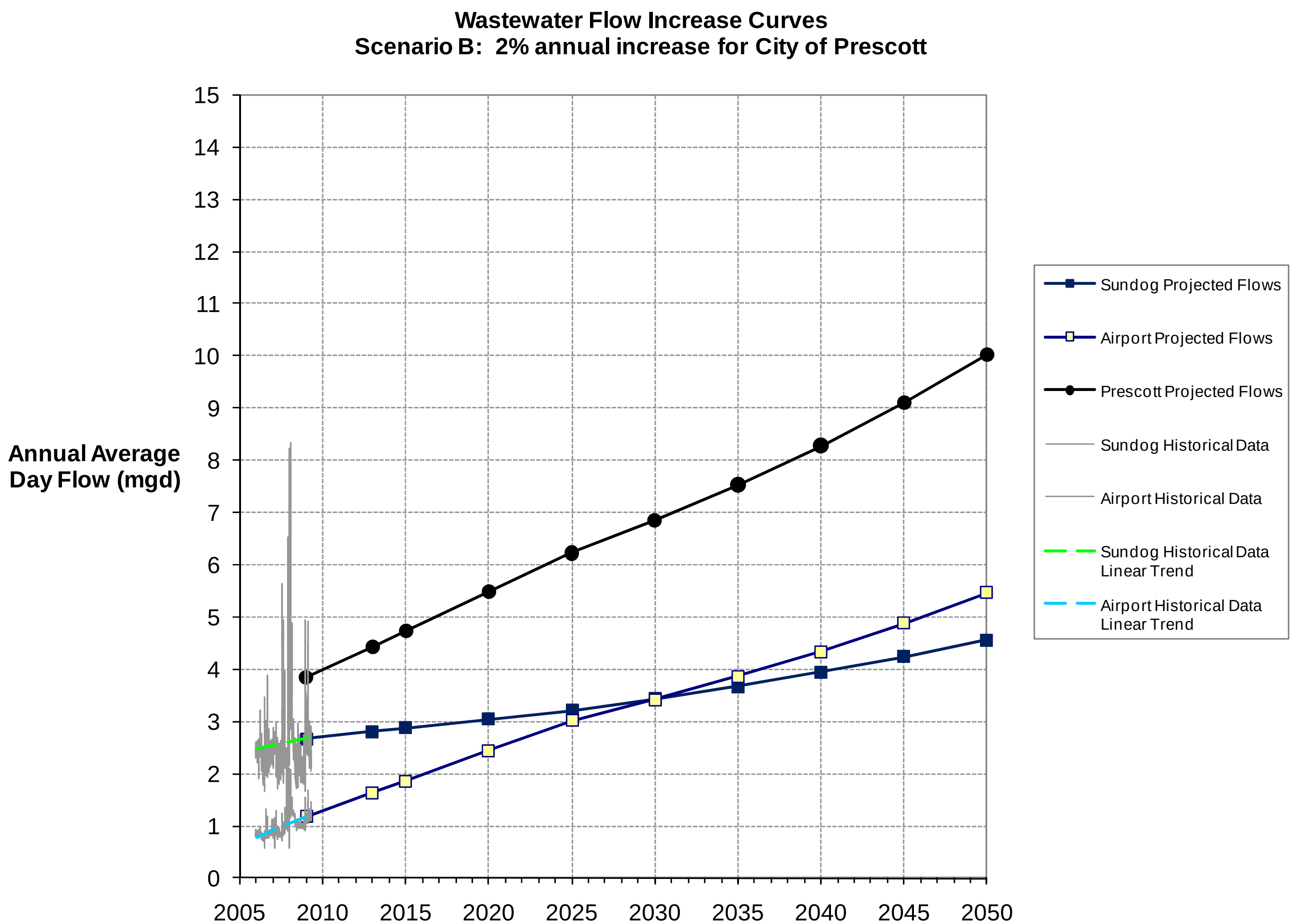
CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION



FLOW INCREASE CURVES – SCENARIO B (CONSERVATIVE)

FIGURE ES5A.2

In Association with carollo

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

The buildout annual average day flow (AADF) for the Airport WRF tributary area is 9.5 mgd (City of Prescott Wastewater Master Plan). For the purposes of this technology assessment and site master planning project, the buildout capacity was established at 9.6 mgd.

The capacity for each phase of the master planned capacity was established at 3.2 mgd (three treatment trains total). This capacity was established based on discussions with the City in several workshops, and it addresses the City's need of having additional treatment capacity beyond the permitted capacity of the existing plant (2.2 mgd). This Phase 1 capacity is more cost-effective than a four treatment train alternative, and it also provides a reasonable timeframe before the next capacity expansion is required.

Based on the flow increase scenarios presented above, Figure ES5A.3 shows the expected timing associated with a first phase of 3.2 mgd. It is estimated that with a Phase 1 capacity of 3.2 mgd, the Airport WRF would require the next expansion phase to be in service as early as the Year 2018 and as late as the Year 2028.

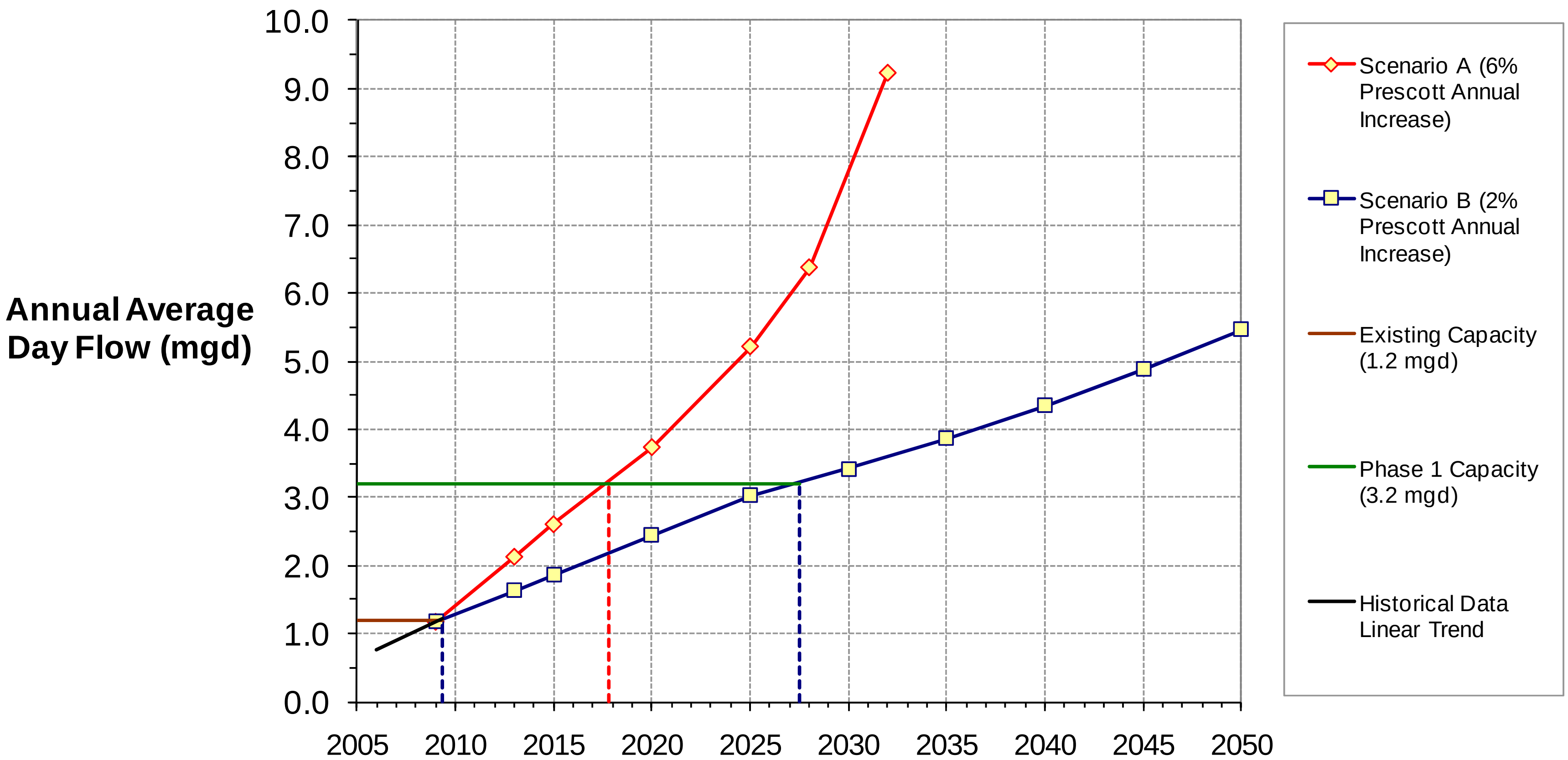
ES5A.3 Alternative Treatment Technologies Screening

For the initial evaluation of process alternatives, a full range of twelve treatment options were considered for completeness. While common process technologies at each plant were not a requirement of the master plan, there are significant advantages to the City with common or compatible processes. The full range of treatment alternatives were reviewed and discussed in project workshops with the City. There was a project team consensus that two alternatives should be brought forward for detailed evaluation:

- Alternative 1 – conventional activated sludge with Modified Ludzack-Ettinger Process (MLE) for biological nitrification and denitrification
- Alternative 2 – Membrane Bioreactor (MBR) with MLE for biological nitrification and denitrification

ES5A.4 Alternative 1 – Conventional MLE

Figure ES5A.4 presents the preliminary site plan for the conventional treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown outside the 350-feet internal setback from the property boundary.



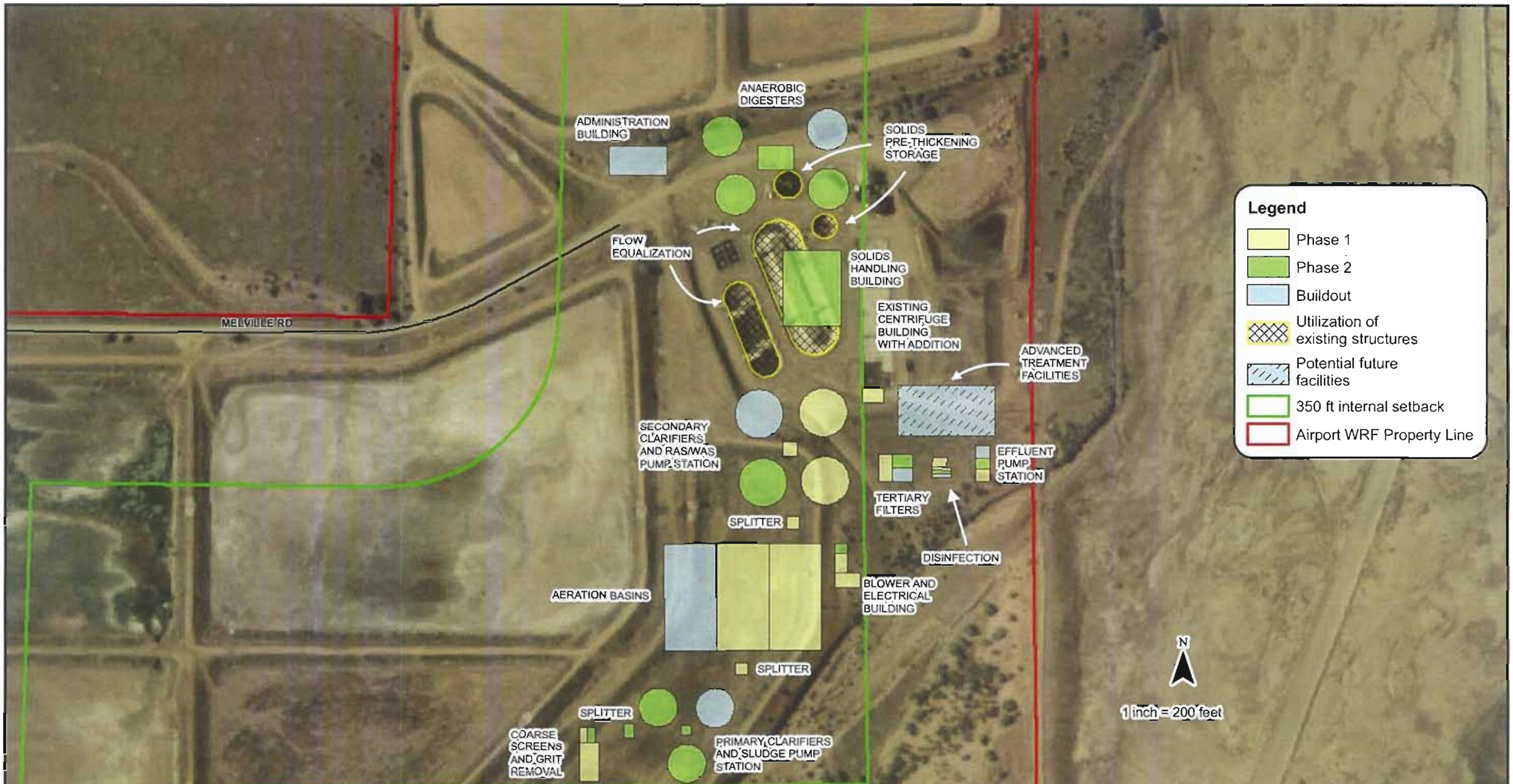
FLOW INCREASE CURVES – AIRPORT WRF

FIGURE ES5A.3

In Association with carollo

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION



CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE SITE PLAN
FIGURE ES5A.4

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5A - AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

ES5A.5 Membrane Treatment Alternative

Figure ES5A.5 presents the preliminary site plan for the membrane treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown outside the 350-feet internal setback from the property boundary.

ES5A.6 Alternatives Comparison

An economic comparison of the two treatment alternatives for buildout conditions is presented in Table ES5A.9.

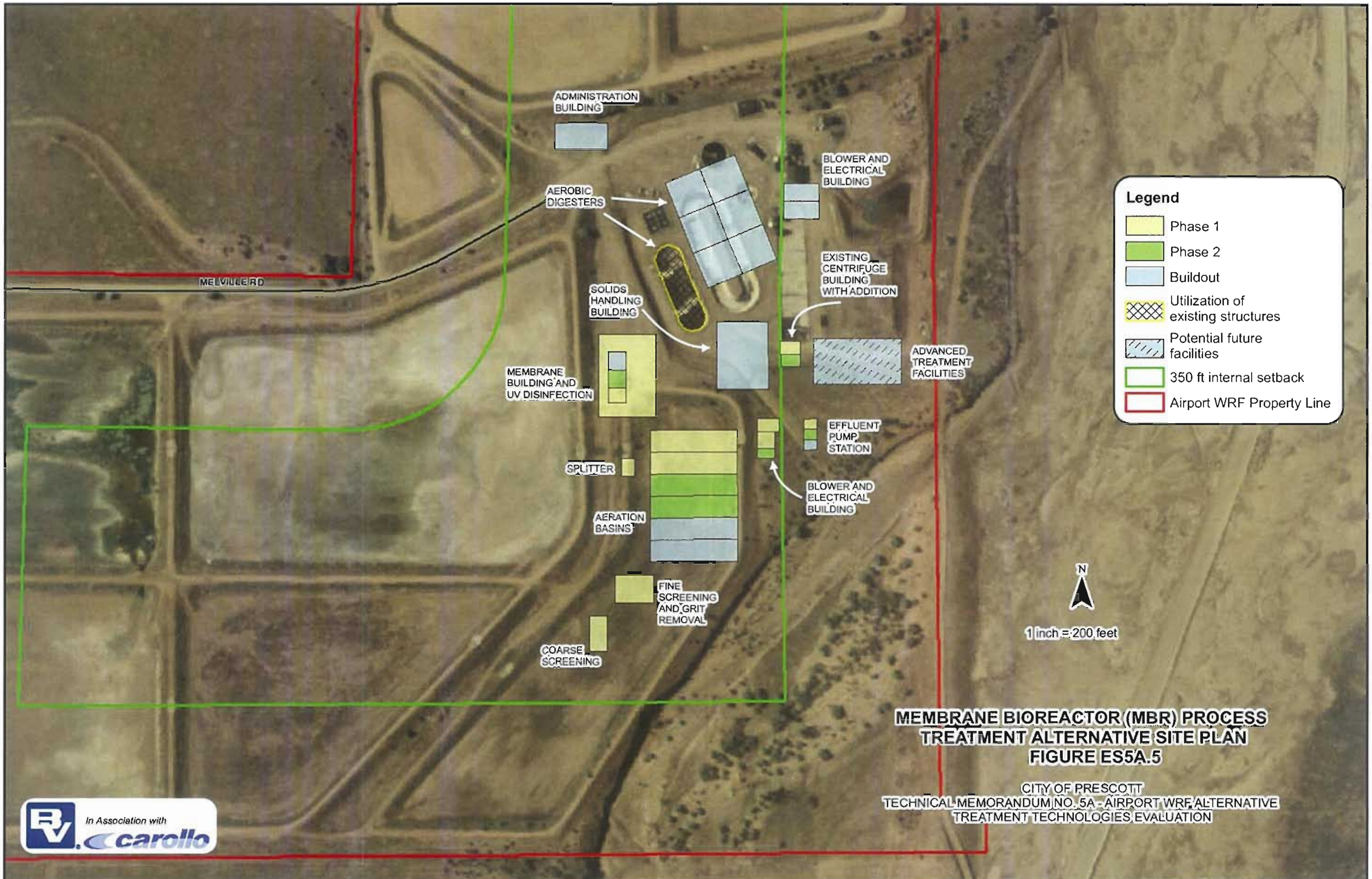
**Table ES5A.9 Treatment Alternatives Economic Comparison for Buildout (9.6 mgd)
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona**

Criteria	Conventional (MLE) Treatment Alternative	Membrane (MBR) Treatment Alternative
Estimated Construction Cost	$121,864,000	$124,512,000
Annual Operations and Maintenance Costs	$3,631,000	$4,860,000
Total Life-Cycle Cost (1)	$171,744,000	$191,282,000

Note:

(1) As present value, assuming life-cycle period of 20 years, interest rate of 6 percent, and escalation rate of 2 percent.

The technology evaluation process also considered non-economic factors. Table ES5A.10 shows a relative comparison of the treatment technologies.



MEMBRANE BIOREACTOR (MBR) PROCESS TREATMENT ALTERNATIVE SITE PLAN
FIGURE ES5A.5

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5A - AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

Date Printed: July 20, 2010

Table ES5A.10	Treatment Alternatives Non-Economic Comparison Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona				
		Alternative 1 – Conventional MLE		Alternative 2 – MBR	
Criteria	**Weighing Factor**	**Raw Score**	**Weighted Score**	**Raw Score**	**Weighted Score**
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
Instrumentation and Controls Intensity	x 3	8	24	4	12
Compatibility with Advanced Treatment Processes	x 2	5	10	8	16
Sustainability and Reuse	x 3	6	18	8	24
TOTAL OVERALL SCORE	-	-	**156**	-	**150**

Note:
(1) Comparison of non-economic factors where 10 = best and 1 = worst

ES5A.7 Liquid Secondary Treatment Recommendation

The economic evaluation presented herein shows that the capital costs of the conventional (MLE) process and the MBR process alternatives are practically the same given the accuracy of the cost estimates prepared for this effort. However, the conventional (MLE) process alternative has the lowest total life cycle costs, including operation and maintenance costs. The conventional (MLE) process also has a significantly lower Phase 1 capital cost compared to the MBR process alternative.

The non-economic evaluation presented in Section ES5A.6 shows that the conventional (MLE) process alternative had a higher score (better) than the MBR process alternative when considering non-economic factors.

Based on the results of the economic and non-economic evaluation, and discussions with City staff on project workshops, the recommended liquid secondary treatment technology for the Airport WRF is the conventional (MLE) activated sludge process.

The recommended process is compatible with advanced treatment processes with the addition of process units downstream of the MLE treatment process, such as membrane filtration and advanced oxidation processes. This flexibility allows the City to pursue advanced treatment in the future, depending on future requirements and regulations.

ES6 TM 6 – AIRPORT WRF CENTRALIZED TREATMENT FEASIBILITY ANALYSIS

ES6.1 Introduction

TM 5S and TM 5A presented recommendations for improvements at the Sundog WWTP and Airport WRF based on both plants maintaining treatment for its respective collection system tributary areas. This TM 6 considers discontinuing treatment at the Sundog WWTP, conveying all wastewater to the Airport WRF and centralizing treatment at the Airport WRF.

ES6.2 Existing Facilities

The existing treatment facilities at the Sundog WWTP and Airport WRF were described in detail in TM 3S and TM 3A respectively.

ES6.3 Reclaimed Water Pipeline Rehabilitation Alternatives

An 18” / 24” pipeline conveys reclaimed water from the Sundog WWTP to the aquifer recharge basins near the Airport WRF. Converting the Sundog reclaimed water pipeline for conveyance of raw wastewater would require rehabilitation for corrosion protection. Epoxy lining could be used to provide corrosion protection, however that approach would provide no structural integrity and would required periodic inspection and maintenance. Since the pipeline has not been inspected for 20 years due to continual use, only rehabilitation techniques that provide some structural integrity as well as corrosion protection were considered. The following rehabilitation alternatives were considered:

- Fold & Form
  - ✓ Polyvinyl chloride (PVC) or polyethylene (PE) non-reinforced liner.
  - ✓ Folded liner pipe reinforced with a circular woven polyester yarn (PRP).
  - ✓ Insitaform Polyfold – proprietary fold & form installation process using a custom designed close fitting polyethylene (PE) pipe.
- Swagelining
  - ✓ Thin wall polyethylene semi-structural liner option.
  - ✓ Thick wall polyethylene structural liner option.

- Cured In Place Pipe – resin impregnated seamless reconstruction sock type tube expanded in place with steam or hot water.

- Slip Lining – solid thermoplastic liner pipe pulled or pushed into the pipe with the annual space filled with grant.

- Pipe Bursting – using a hydraulically or pneumatically driven cone to burst the existing pipe while simultaneously feeding a replacement flexible pipe.

ES6.4 Existing Reclaimed Water Pipeline Hydraulic Analysis

The existing reclaimed water pipeline was installed 20 years ago with a design capacity of 7.5 mgd and Hagen-Williams friction coefficient (C value) of 110. For the centralized treatment approach the required peak wastewater conveyance capacity would be 10.8 mgd. In addition, pipe rehabilitation alternatives will reduce the pipe diameter. After rehabilitation with a thin wall smooth liner pipe (C2150) the 24 inch portion of the reclaimed water pipeline would provide sufficient for 10.8 mgd, however, the 18 inch segment would not.

ES6.5 Combination Reclaimed Water Pipeline with Airport WRF

The Sundog reclaimed water pipeline passes near the Willow Creek Intake along Highway 89 approximately half way between the Sundog WWTP and Airport WRF. There is an existing 24 inch diameter trunk sewer originating near the Willow Creek Intake which conveys wastewater to the Airport WRF. There is the potential to make use of this trunk sewer to convey raw wastewater from the Sundog WWTP to the Airport WRF in combination with the 24 inch portion of the Sundog reclaimed water pipeline.

ES6.6 Wastewater Conveyance and Reclaimed Water Distribution

The Prescott Lakes Golf Course and area is currently supplied reclaimed water from the Sundog reclaimed water pipeline. If treatment is discontinued at the Sundog WWTP and the reclaimed water pipeline converted to wastewater conveyance, an alternative for reclaimed water distribution is required. Two overall wastewater conveyance and reclaimed water distribution alternatives were analyzed. The recommended alternative is shown in Figure ES6.1 and consists of the following elements:

- Rehabilitation of 24” Sundog reclaimed water pipeline for wastewater conveyance from the Sundog WWTP to Prescott Lakes Reclaimed Water PS.

- Utilizing the new 24”and 30” sewer piping from the Prescott Lakes Reclaimed Water PS to the vicinity of the Willow Creek Intake.

- Upsizing an existing trunk sewer from near the Willow Creek Intake to the Airport WRF.
- Continued utilization of the reclaimed water pipeline system for distribution of reclaimed water from the Airport WRF to all existing customers, including Prescott Lakes via the Prescott Lakes Reclaimed Water PS.
- New reclaimed water PS at the Airport WRF.

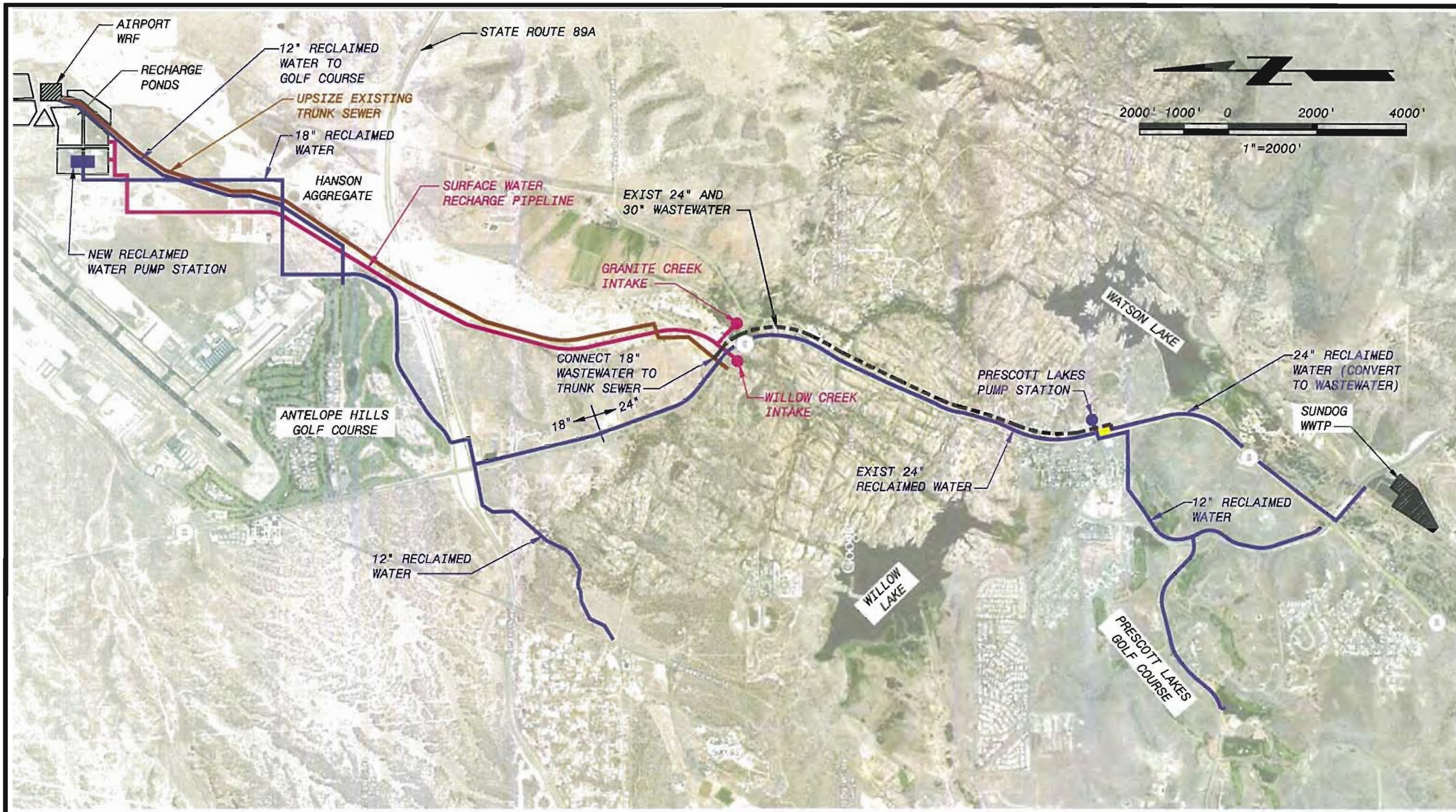


FIGURE ES.1
CENTRALIZED TREATMENT AT THE AIRPORT WRF:
WASTEWATER CONVEYANCE AND
RECLAIMED WATER DISTRIBUTION

ES6.7 Sundog WWTP Improvements

Under the centralized treatment at the Airport WRF approach, wastewater tributary to the Sundog WWTP would be conveyed to the Airport WRF. However, some minor improvements at the Sundog WWTP are still recommended, as follows:

- Maintain the existing preliminary treatment headworks (influent screens and grit removal) with minor improvements to the existing facilities.

- Provide flow equalization to reduce peak flow requirements in the conveyance pipeline.

- Provide odor control for the existing headworks and proposed flow equalization facility.

ES6.8 Airport WRF Improvements

The treatment technology recommended for the Airport WRF would be as recommended in TM 5A. The difference for the centralized approach is planning for an ultimate combined Sundog WWTP and Airport WRF capacity of 15 mgd rather than 9.6 mgd.

Planning for the larger ultimate capacity alters the recommended initial capacity and subsequent modular expansion capacities. As noted on Page ES-44, cost estimates in TM 5A are based on three Airport WRF modules of 3.2 mgd capacity each (9.6 mgd ultimate capacity). Under the centralized treatment approach (TM 6) phasing and cost estimates are based on four modules of 3.75 mgd each (15 mgd ultimate capacity).

The ultimate and Phase 1 design wastewater flows and peaking factors used for evaluation of centralized treatment at the Airport WRF are presented in Table ES6.1 and ES6.2.

Table ES6.1 Buildout Design Wastewater Flows and Peaking Factors
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Flow Criteria	Airport WRF Buildout Flow, mgd[1]	Sundog WWTP Buildout Flow, mgd [1,2]	Combined Buildout Flow at Airport WRF, mgd [1,3]	Combined Hydraulic Peaking Factor [1,3]
Annual Average Day Flow	9.6	5.4	15.0	1.00
Maximum Month Average Day	13.4	10.8	24.2	1.62
Peak Day	19.2	10.8	30.0	2.00
Peak Hour	28.8	10.8	39.6	2.64

Notes:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.
(2) Based on the assumption that flow equalization facilities and/or collection system improvements result in peaking factors no greater than 2.0 for the Sundog WWTP service area flows.
(3) Based on the assumption that peak flows for the Airport WRF and Sundog WWTP service areas coincide when combined at the Airport WRF.

Table ES6.2 Phase 1 Design Wastewater Flows and Peaking Factors
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Flow Criteria	Phase 1 Flow, mgd	Hydraulic Peaking Factor[1]
Annual Average Day Flow	3.75	1.0
Maximum Month Average Day	5.25	1.4
Peak Day	7.50	2.0
Peak Hour	11.25	3.0

Note:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

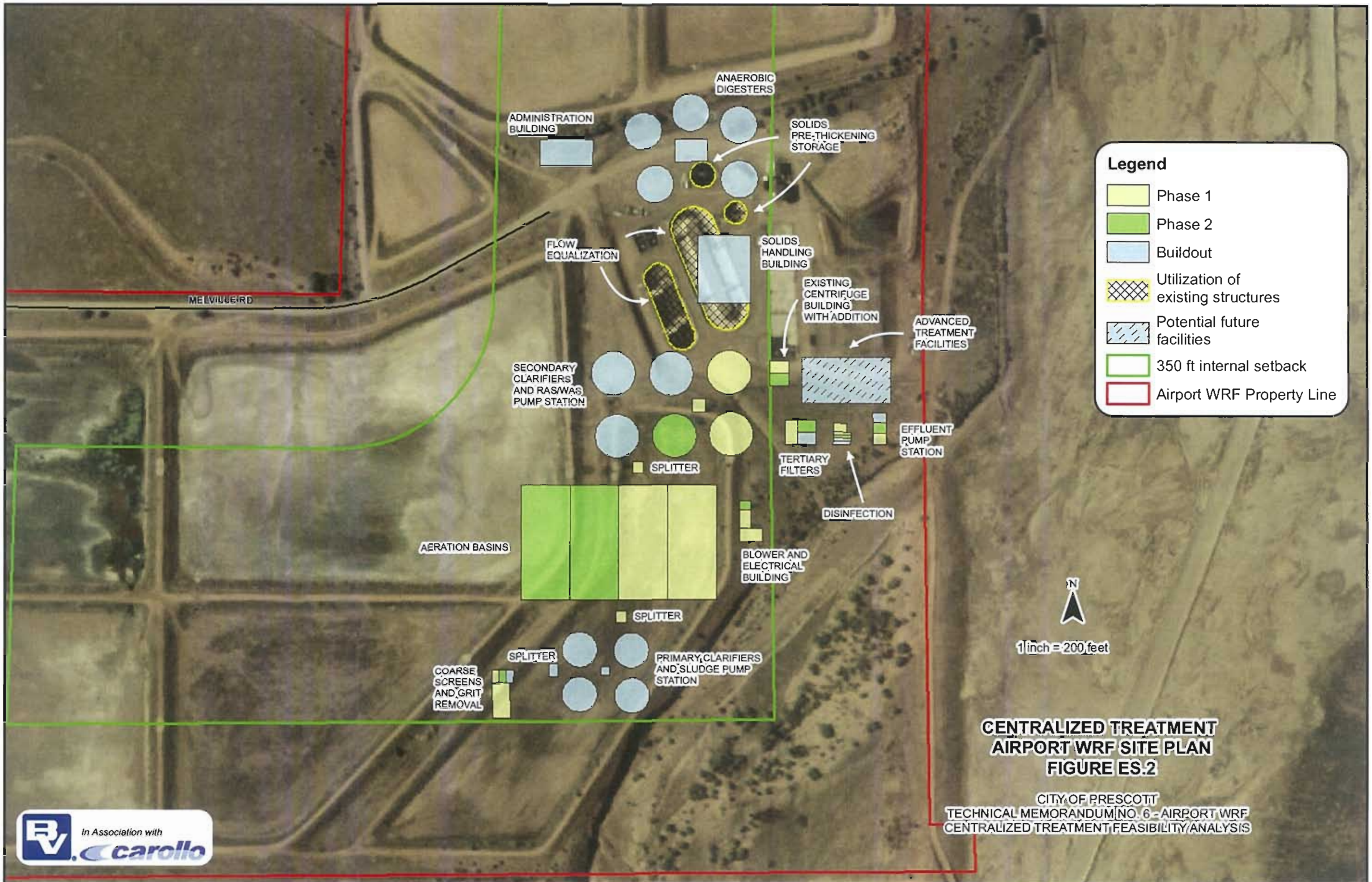
For centralized treatment at the Airport WRF, design wastewater characteristics are a compilation of characteristics observed at the existing Sundog WWTP and Airport WRF, Design characteristics for centralized treatment at the Airport WRF are presented in Table ES6.3.

Table ES6.3 Design Wastewater Characteristics Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona Centralized Treatment Feasibility Analysis			
Design Parameter	**Unit**	**Annual Average Day**	**Maximum Month Average Day (1)**
Flow	mgd	3.75	5.25
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity	mg/L	250	250
Temperature	°C	18.4	12.4

Note:

(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).

Figure ES6.2 presents a site plan of the recommended Airport WRF improvements for centralized treatment.



CENTRALIZED TREATMENT AIRPORT WRF SITE PLAN FIGURE ES.2

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 6 - AIRPORT WRF
CENTRALIZED TREATMENT FEASIBILITY ANALYSIS

ES6.9 Decentralized Versus Centralized Treatment Comparison

The two approaches were evaluated based on economic and non-economic criteria.

ES6.9.1 Economic Comparison

A capital cost operating cost and present worth comparison of decentralized treatment versus centralized treatment are presented in Tables ES6.4 and ES6.5 respectively. The capital costs for decentralized treatment were brought forward from TM 5S and TM 5A.

Table ES6.4 Capital/Operating Cost and Present Worth for Decentralized Treatment at Sundog WWTP and Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP (5.4 mgd) (Build-out)	75.1	2.60	110.75
Airport WRF (9.6 mgd) (Build-out)	115.4	3.63	160.63
	190.5	6.23	271.38

Note:
1 20 yr Present Worth @ 5% interest.

Table ES6.5 Capital/Operating Cost and Present Worth for Centralized Treatment at Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP	10.4	0.5	17.27
Conveyance	5.3	0.2	8.05
Airport WRF (15 mgd)	160.7	4.73	225.66
	176.4	5.43	250.98

Note:
1 20 yr Present Worth @ 5% interest.

ES6.9.2 Non-Economic Comparison

The following non-economic criteria were used to compare decentralized versus centralized treatment:

- Effluent Quality & Permit Compliance
- Aging Infrastructure
- Operational Complexity
- Staffing/Requirements
- Training
- Ease of Maintenance

The criteria were weighted by importance from 1 to 4 and given a rating score from 1 to 10. Results of the non-economic comparison are presented in Table ES6.6.

Table ES6.6 Non-Economic Factor Comparison
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Weighting Factor	Continued Decentralized Treatment at Sundog WWTP and Airport WRF		Centralized Treatment at Airport WRF	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Effluent Quality	x 5	7	35	8	40
Aging Infrastructure	x 4	6	24	9	36
Operational Complexity	x 4	5	20	7	28
Staffing/Training Requirements	x 3	5	15	7	21
Ease of Maintenance	x 4	5	20	7	28
TOTAL			114		153

Note:
1. Comparison of non-economic factors where 10 = best and 1 = worst

ES6.10 Alternative Phasing and Capital Improvement Plans

The previous economic comparison was based on the costs of ultimate build-out facilities. Differences in phasing, initial cost and long term capital improvement plans were also reviewed relative to decentralized versus centralized treatment.

ES6.10.1 Centralized Treatment Phasing Plan

Projected flow curves for the Sundog WWTP (Figure ES6.3) and combined Sundog WWTP and Airport WRF (Figure ES6.4) flows were used to identify timing of phased expansions for centralized treatment and the time frame for the City to decide between the centralized and decentralized treatment approaches.

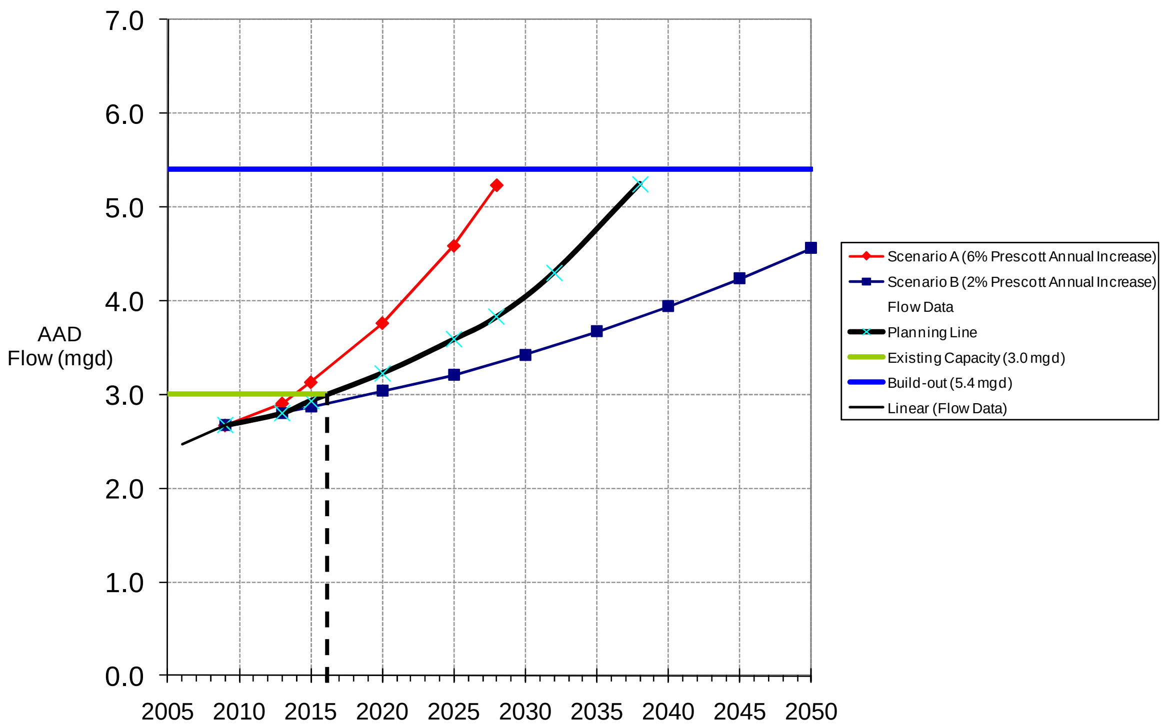


Figure ES6.3 Flow Increase Curves – Sundog WWTP

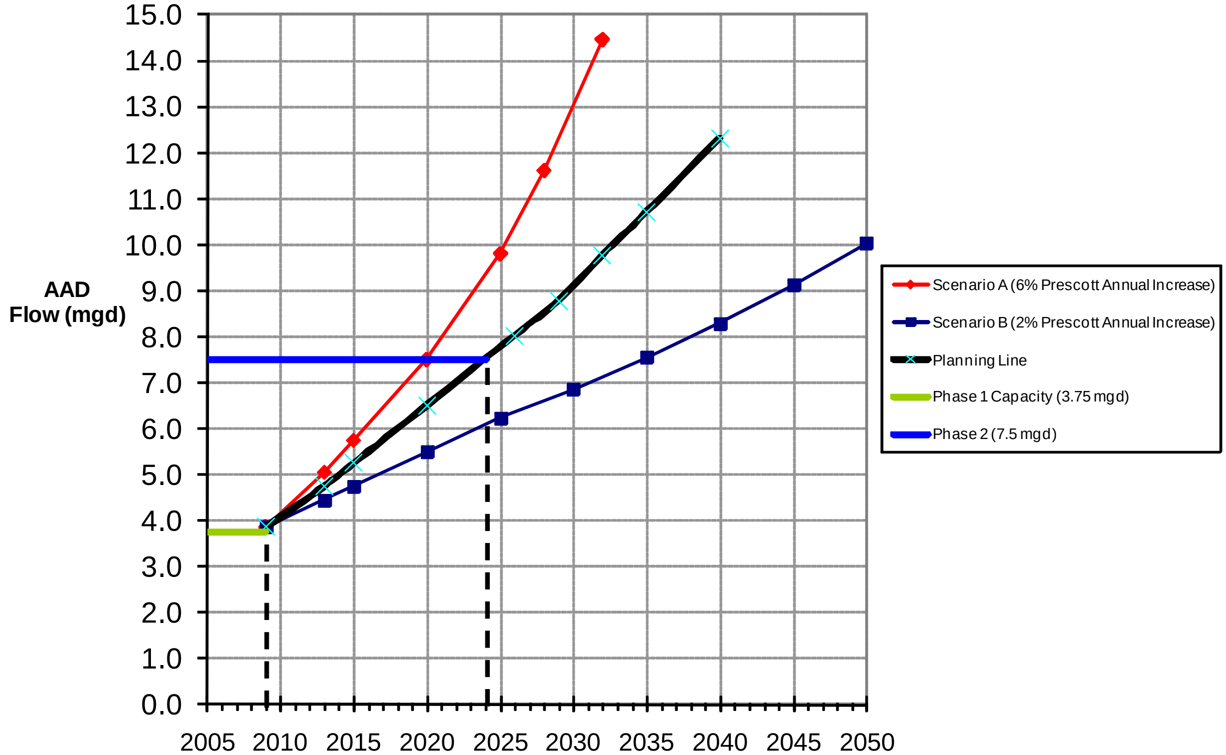


Figure ES6.4 Flow Increase Curves – Combined Sundog WWTP and Airport WRF

Based on flow projections, Figure ES6.5 identifies a schedule of improvements and an associated capital improvements program for centralized treatment.

The time to decide between centralized versus decentralized treatment depends on the life expectancy of the Sundog WWTP. Based on Figure ES6.3, that point is projected to occur in 2019. Allowing for time to design and implement improvements in 3 years, the decision point is identified in 2016.

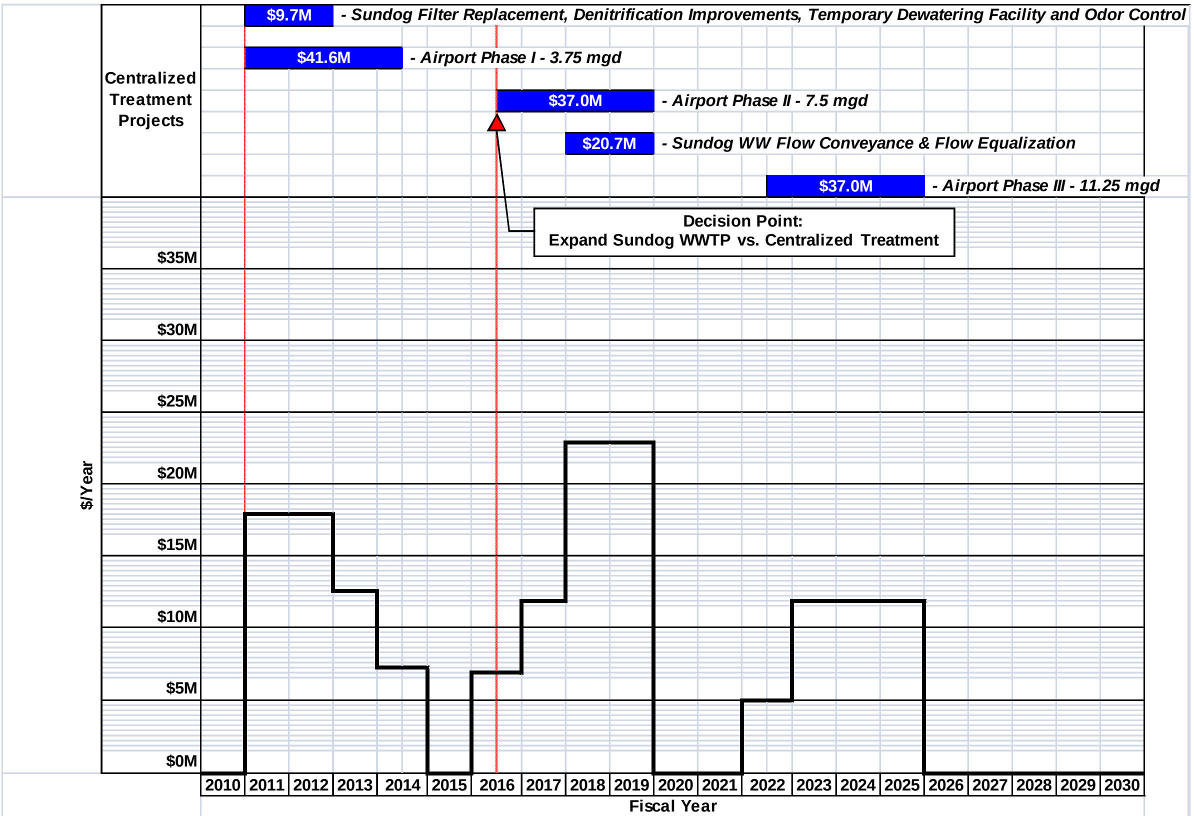


Figure ES6.5 Centralized Treatment CIP

ES6.10.2 Decentralized Treatment Phasing Plan

Figure ES6.6 presents the schedule of individual plant improvements and an associated capital improvements program for the decentralized treatment approach.

A comparison of cumulative capital costs for the centralized versus decentralized approaches is presented on Figure ES6.7.

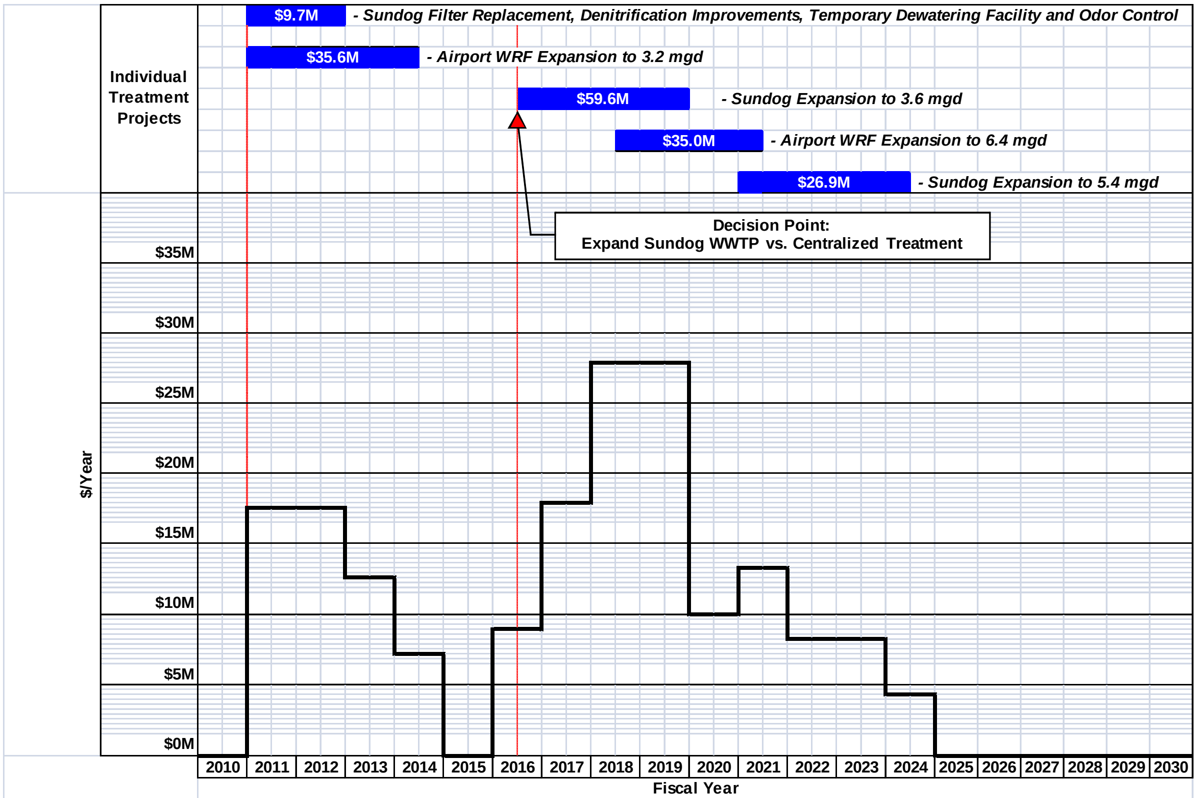


Figure ES6.6 Decentralized Treatment Plants CIP

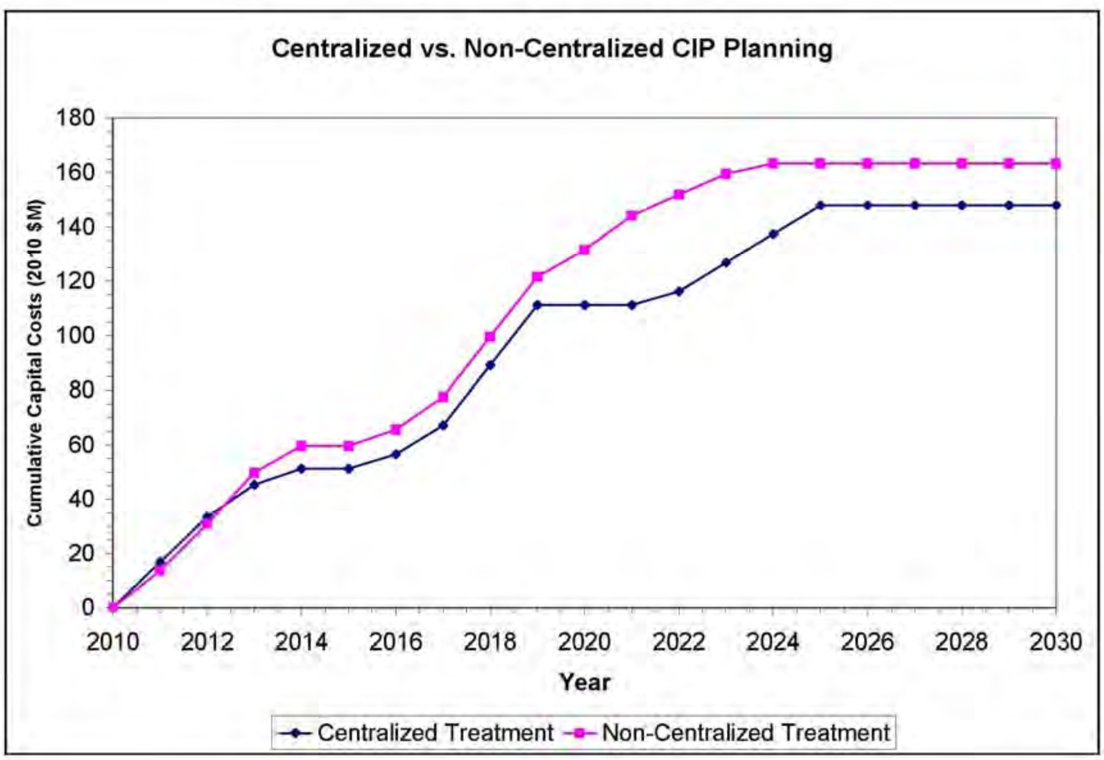


Figure ES6.7 Cumulative Capital Cost Comparison

ES6.11 Conclusions

The economic comparison (20-year present worth), non-economic comparison and the comparison of phasing plans and corresponding capital improvement plans show minor difference between centralized treatment at the Airport WRF and decentralized treatment at the Airport WRF and Sundog WWTP. It is recommended the City maintain both options for as long as possible. As such the following recommendations and conclusions are appropriate.

- Plan the first phase of the Airport WRF improvements for 3.75 mgd of capacity which provides the flexibility for either approach.
- Recognize that an initial capacity of 3.75 mgd for the Airport WRF does not dictate the centralized treatment approach.
- Plan to make a decision on centralized treatment 2016, provided the actual flow increases are consistent with the projections herein.
- Recognize that if actual flow increase are less than projected the centralized treatment decision can be postponed beyond 2016.
- Consider collection system alternatives to divert flow away from the Sundog WWTP to the Airport WRF. This will in effect prolong the life expectancy of the Sundog WWTP and postpone the centralized treatment decision point.
- Consider more aggressive approach to solving I/I problem vs. providing flow equalization.

ES7 TM 7 – TERTIARY FILTRATION EVALUATION

ES7.1 Introduction

The purpose of this technical memorandum is to evaluate alternative tertiary filtration technologies for the Sundog WWTP and Airport WRF.

ES7.2 Background

The last major expansion of the Sundog WWTP liquid treatment process, including filters, was constructed in 1990. The existing tertiary filtration process consists of two traveling bridge filters. The filters have historically met all discharge permit limits, without significant operator complaints. The filters have recently experienced failures in the porous plates. The existing filters need to be rebuilt or replaced.

The most recent expansion of the Airport WRF occurred in 1998 and included the addition of one traveling bridge filter. Plant staff have reported ongoing plugging issues with the porous plate in the existing unit. Also, there is a lack of redundancy and the filter cannot be taken off-line and cleaned thoroughly without losing the ability to filter secondary effluent prior to UV disinfection.

ES7.3 Hydraulic Design Criteria

Projected annual average wastewater flows tributary to the Sundog WWTP and Airport WRF are presented in Table ES7.1

Table ES7.1 Projected Wastewater Flows

	Sundog WWTP			Airport WWTP		
	2010	2015	Buildout	2010	2015	Buildout
Master Plan AAD	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	4.9 mgd
West Area AAD	---	---	---	0	0	2.2 mgd
Granite Creek AAD	---	---	---	TBD	TBD	2.0 mgd
Total	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	9.1 mgd

The Sundog WWTP collection system experiences significant wet weather inflow and infiltration, as illustrated in Figure ES7.1.

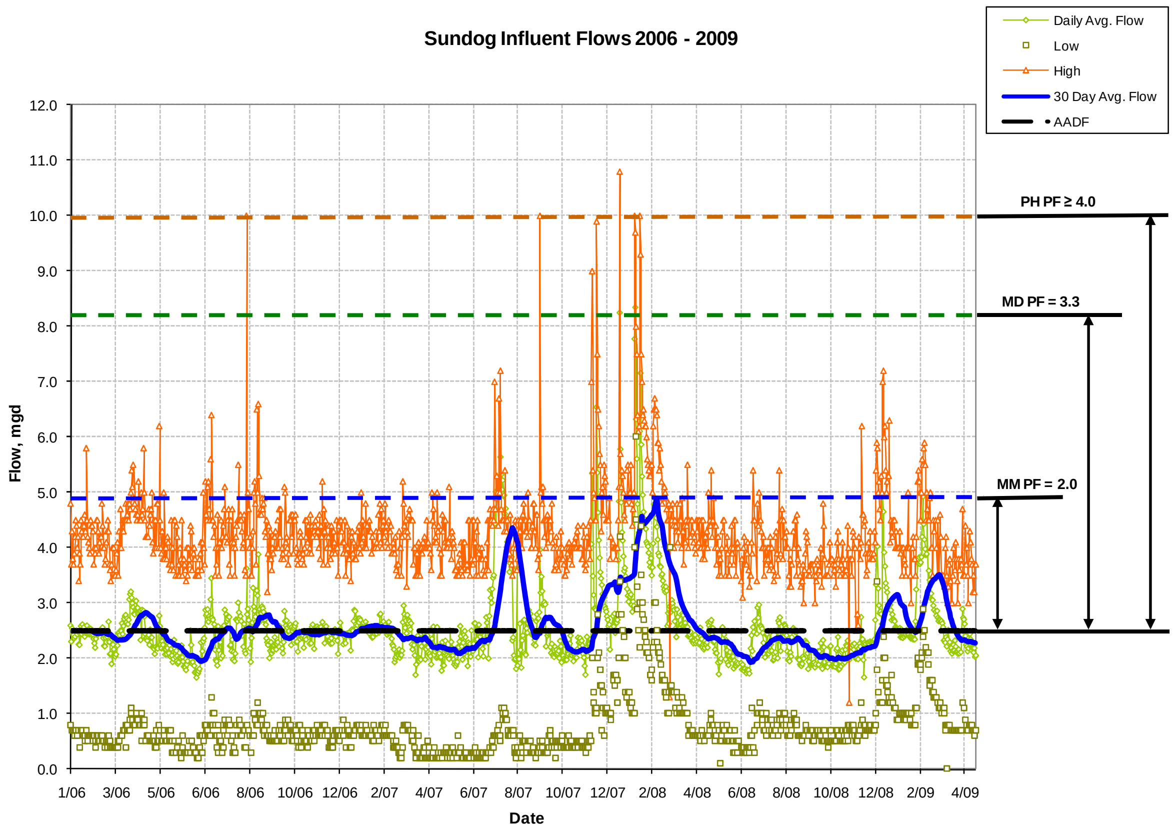


Figure ES7.1 Monthly Sundog WWTP Floes 2006 - 2009

Based on this data it is recommended to design the Sundog WWTP filters for a maximum month hydraulic flow capacity of 2.0 times average annual design capacity and rely on flow equalization to store excess wet weather flows above maximum month flow. Therefore, build out hydraulic capacity of the Sundog WWTP filters should be 10.6 mgd, with one unit out of service.

The impact of wet weather infiltration and inflow is not as great at the Airport WWTP, as shown in Figure ES7.2.

A hydraulic design capacity of 2.0 times average annual flow or 18.2 mgd for the build out condition is recommended for the Airport WWTP filters. Flow equalization is recommended to store and equalize flows is excess of peak day flow.

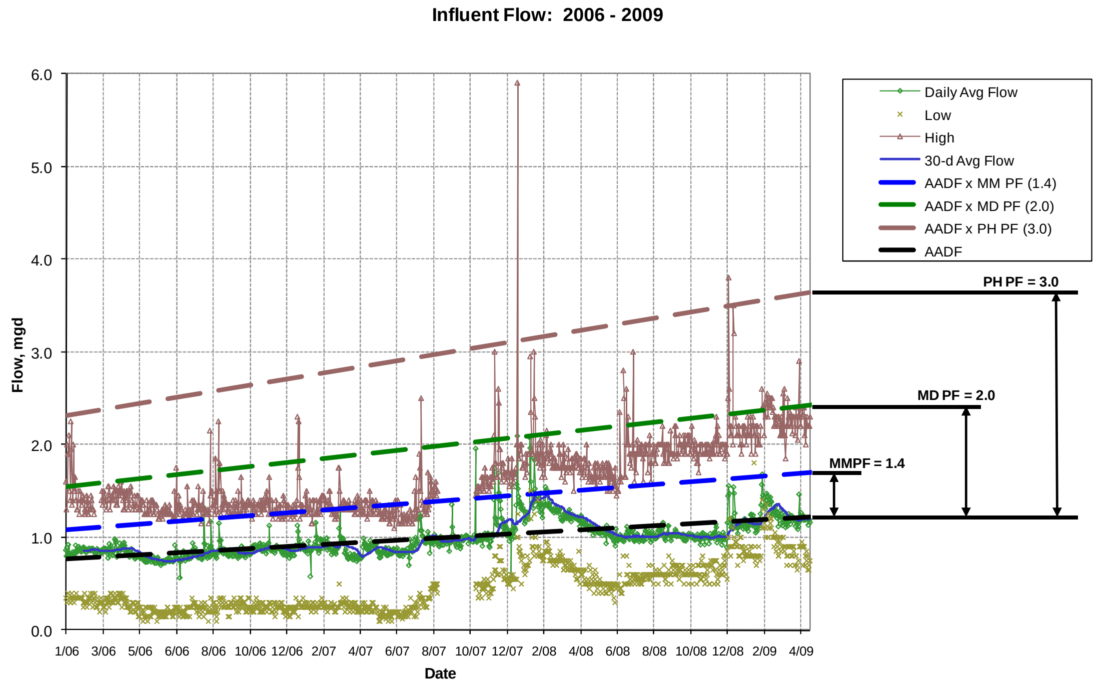


Figure ES7.2 Monthly Airport WWTP Floe 2006 - 2009

ES7.4 Required Reclaimed Water Quality

The current project will evaluate tertiary filtration technologies that are capable of producing Class A+ effluent. The current water quality standards for Class A+ Reclaimed Water are shown in Table ES7.2.

Table ES7.2 Class A+ Reclaimed Water Quality Standards	
Parameter	**Treatment Standard**
Turbidity, NTU	
• Average	2
• Single sample max	5
Fecal Coliform, cfu/100mL	
• 4 of last 7 samples	Non-detect
• Single sample max	23
APP	
• BADCT	THM control

Historical filter performance at both the Sundog WWTP and Airport WRF has met Class A+ average turbidity of ≤2 NTU, except for periods of extreme wet weather flows. However, the Sundog WWTP filters have recently experienced structural failure of the media support porous plate and are out of service.

ES7.5 Filtration Alternatives

The following filtration alternatives were considered:

- Existing Traveling Bridge Filter Retrofit
  - ✓ Conventional underdrain replacement – Infilco (ABF)
  - ✓ Pipe underdrain replacement – Siemens (Gravisand)
- Disk Filter Technology
- Cloth Media Filters – Aqua Aerobics (AquaDiamond)
- Compressible Media Filter – Schreiber (Fuzzy Filter)
- Upflow Continuous Backwash Filters
- Conventional Deep Bed Filtration
- Microfiltration
  - ✓ Submerged – General Electric
  - ✓ Pressure Vessels – Siemens, Pall

ES7.6 Comparison of Tertiary Filtration Technologies

Hydraulic loading criteria varies for each of the filtration technologies. The resulting basis of design for each technology for the Sundog WWTP and Airport WRF are presented in Table ES7.3 and Table ES7.4.

Table ES7.3 Sundog WWTP Filtration Basis of Design Criteria						
Filter Technology	**Total Surface Area, ft^2**		**No. Units Required**		**New Concrete Basin or Structure**	**Pump Station Required**
	Average	**Peak (Max Month)**	**Duty**	**Standby**		
Traveling Bridge Filters	**3,120**	**3,120**	2	1	yes	no
Disk Filters	**1,764**	**1,764**	2	1	no	no
Cloth Media Filters	**2,600**	**2,600**	1	1	no	no
Compressible Media Filters	174	**253**	4	1	yes	yes
Upflow Continuous Backwash Filters	1,146	**1,526**	27	1	yes	yes
Conventional Filters	**2,400**	1,964	4	1	yes	yes
Microfiltration (2)	132,500	**265,000**	11	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based on a standard 50 module rack.

Table ES7.4 Airport WWTP Filtration Basis of Design Criteria						
Filter Technology	**Total Surface Area, ft^2**		**No. Units Required**		**New Concrete Basin or Structure**	**Pump Station Required**
	Average	**Peak (Peak Day)**	**Duty**	**Standby**		
Traveling Bridge Filters	**4,025**	**4,025**	6	1	yes	no
Disk Filters	**2,750**	**2,750**	4	1	yes	no
Cloth Media Filters	**4,160**	**4,160**	1	1	yes	no
Compressible Media Filters	294	**400**	7	1	yes	yes
Upflow Continuous Backwash Filters	1,953	**2,582**	47	1	yes	yes
Conventional Filters	**4,200**	3,600	6	1	yes	yes
Microfiltration (2)	227,500	**455,000**	19	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based upon a standard 50 module rack.

Tertiary filtration alternatives were compared based on economic and non-economic criteria.

A capital, operating and life cycle present worth cost comparison of filtration technologies for the Sundog WWTP and Airport WRF are presented on Table ES7.5 and Table ES7.6 respectively.

Table ES7.5 Sundog WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Compressible Media	Upflow Filters	Conventional	Microfiltration
Capital Cost	$1,950,000	$2,166,000	$2,836,000	$2,970,000	$3,039,000	$4,740,000	$13,487,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance (parts only)	$6,200	$8,400	$4,100	$800	$1,400	$10,300	$51,000
Power ($0.10/kWH)	$8,100	$2,400	$5,900	$16,700	$16,700	$16,400	$52,600
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$114,000
Total Life Cycle Cost w/o UV	**$2,300,000**	**$2,500,000**	**$3,200,000**	**$3,400,000**	**$3,500,000**	**$5,300,000**	**$16,600,000**
UV Power	$63,100	$63,100	$63,100	$63,100	$63,100	$63,100	$19,300
Total Life Cycle Cost w/ UV	**$3,000,000**	**$3,200,000**	**$3,900,000**	**$4,100,000**	**$4,200,000**	**$6,000,000**	**$16,800,000**

Table ES7.6 Airport WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Fuzzy Filter	Upflow Filters	Deep Bed	Microfiltration
Capital Cost	$4,838,000	$3,818,000	$4,640,000	$4,541,000	$4,812,000	$11,676,000	$22,423,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance	$14,000	$13,000	$4,000	$5,000	$2,000	$14,000	$42,000
Power	$19,000	$4,000	$6,000	$17,000	$16,000	$16,000	$43,000
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$93,000
Total Life Cycle Cost w/o UV	**$5,400,000**	**$4,200,000**	**$5,000,000**	**$5,000,000**	**$5,200,000**	**$12,200,000**	**$25,100,000**
UV Power	$110,000	$110,000	$110,000	$110,000	$110,000	$110,000	$39,000
Total Life Cycle Cost w/ UV	$6,700,000	$5,500,000	$6,200,000	$6,300,000	$6,500,000	$13,500,000	$25,500,000

Table ES7.7 shows a relative comparison of the filtration technologies based on a score of 1 through 10 (higher value means more desirable). A multiplier was also applied to each of the non-economic factors to properly weigh those factors most important to the City.

ES7.7 Recommendations

The recommended tertiary filtration alternative for implementation at the Sundog and Airport WWTPs is disk filters. Disk filters provide a good mixture of low cost, reliable performance and low maintenance

Table ES7.7 Non-Economic Factor Comparison

	Effluent Quality		Proven Technology		Operational Complexity		Compatibility with Future AOPs		Footprint		Total Overall Score
Weighting Factor	**x 5**		**x 4**		**x 3**		**x2**		**x2**		
Treatment Technology	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	
Traveling Bridge Filter	7	35	9	36	6	18	5	10	4	8	107
Disk Filters	7	35	9	36	8	24	5	10	8	16	121
Cloth Media Filters	7	35	7	28	7	21	5	10	6	12	106
Compressible Media Filters	6	30	4	16	5	15	3	6	8	16	83
Upflow Filters	5	25	8	32	6	18	3	6	6	12	93
Conventional Filters	7	35	9	36	3	9	5	10	3	6	96
Microfiltration	10	50	7	28	4	12	10	20	4	8	118

Comparison of non-economic factors where 10 = best and 1 = worst

ES8 TM 8 – BIOSOLIDS PLANNING CONDITIONS

ES8.1 Introduction

The main objectives of this Technical Memorandum No. 8 are to establish existing conditions and identify future trends in biosolids management. Existing conditions of solids handling equipment, materials, processes, and costs are established. Future trends in regional land use and availability, as well as regulatory issues are identified as they relate to the City's biosolids management program.

ES8.2 Background

Biosolids are typically disposed of in landfills or are beneficially reused through land application. Biosolids disposal and land application is federally regulated by the EPA 40 CFR 503. The Arizona Department of Environmental Quality (ADEQ) enforces the federal regulations and administers the biosolids program in Arizona, with oversight by the U.S. EPA. Table ES8.1 presents a brief summary of the ADEQ, Class A, and Class B biosolids requirements and associated land application restrictions. A more detailed discussion of EQ, Class A, and Class B biosolids regulations are provided in Appendix A of Technical Memorandum No. 8.

Table ES8.1 Biosolids Classifications and Disposal Options Summary
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

	Exceptional Quality	Class A	Class B
Requirement	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Achieve pathogen and vector attraction reduction.
	Reduce pathogen levels to below detectable limits.	Reduce pathogen levels to below detectable limits.	
	Achieve vector attraction reduction via limited options.	Achieve vector attraction reduction.	
	Must meet monthly average metal concentration limits.	Must meet ceiling metal concentration limits and metal loading rates.	

Table ES8.1	Biosolids Classifications and Disposal Options Summary Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona		
	Exceptional Quality	**Class A**	**Class B**
Can be applied to…	Anywhere.	Nurseries, gardens, golf courses, parks, and areas where contact with general public is possible.	Agriculture, landfill, & areas with no potential contact with general public.

ES8.3 Existing Conditions

The Sundog WWTP produces Class B biosolids that are disposed of via land application. Solids handling and treatment facilities at the Sundog WWTP include waste activated sludge (WAS) thickening, anaerobic digestion of combined primary sludge and thickened WAS, and dewatering of digested sludge.

The current solids handling practice at the Airport WRF is dewatering undigested sludge, followed by landfill disposal. WAS is continuously pumped to an aerated solids holding tank, where it is slightly thickened by gravity. The thickened WAS is sent to the centrifuge building for dewatering and subsequent disposal via a roll-off bin.

The current biosolids management program costs include processing, hauling, and disposal of the biosolids generated at the Sundog WWTP and Airport WRF. The costs of the biosolids management program are summarized in Table ES8.2. Since April 2009, biosolids from the Airport WRF are not sent to the Sundog WWTP, and are sent to landfill disposal after dewatering. Biosolids from the Sundog WWTP are disposed of via land application.

The overall unit cost for biosolids management at the Airport WRF is 74 percent higher than the costs at the Sundog WWTP. The main reason for this difference is the higher disposal cost associated with the Airport WRF sludge ($29.50 per wet ton for land application, versus $47.00 per wet ton for landfill disposal).

Table ES8.2 Existing Biosolids Management Program Costs Summary Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona				
Cost [1]	**Sundog WWTP**		**Airport WRF**	
Annual Energy Costs	$41,493	(24%)	$22,888	(21%)
Annual Chemical Costs	$24,220	(14%)	$31,415	(29%)
Annual Biosolids Disposal Costs[2],[3]	$105,394	(61%)	$52,235	(49%)
Annual Miscellaneous Costs	$2,972	(2%)	$301	(0.3%)
Total Annual Operating Costs	$174,079	(100%)	$106,839	(100%)
Biosolids Produced [2]	3,334 wet tons		1,159 wet tons	
Unit Cost	$52.2 / wet ton		$92.2/ wet ton	

Notes:

(1) All costs are based on 2009 process operational data and cost information provided by City of Prescott. A detailed breakdown is presented in Appendix B.

(2) Quantities of Airport WRF biosolids in the first three months of 2009 were estimated using a monthly average of April to December 2009.

(3) The current contract for biosolids transport and disposal establishes a fixed cost of $29.5 per wet ton for land application, and $47.0 per wet ton for landfill disposal.

ES8.4 Biosolids Quantities

Existing and future solids production for the Sundog WWTP and Airport WRF are presented in Table ES8.3.

Table ES8.3 Existing and Projected Biosolids Production – Sundog WWTP and Airport WRF Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona						
	Sundog WWTP Plant Flow	**Airport WRF Plant Flow**	**Sundog WWTP Dewatered Biosolids**		**Airport WRF Dewatered Biosolids**	
	mgd	**mgd**	**lb/day**	**wet tons/ day [2]**	**lb/day**	**wet tons/ day [2]**
Existing [1], AADF	2.6	1.1	3,653	9.1	1,389	3.2
Existing, MMADF	5.2	1.5	6,377	15.9	2,729	6.2
Ultimate, AADF	5.4	9.6	7,588	19.0	16,371	40.9
Ultimate, MMADF	10.8	13.4	13,244	33.1	29,479	73.7

Note:

(1) Based on 2009 operational data

(2) Assumes a total solids concentration of 20 percent.

ES8.5 Biosolids Management Trends

There are no specific new federal regulatory initiatives planned in the near-term. Similar to regulations for liquid processes in wastewater treatment, personal health care products and pharmaceuticals in biosolids is an issue on the horizon, but no impending regulatory programs are envisioned to address these compounds in the near future.

There are no formal restrictions for the land application of biosolids in the State of Arizona. However, a number of counties in California have implemented full or partial bans of Class B biosolids land application. Others have restricted the application of biosolids entirely - regardless of their classification.

Most facilities in Arizona produce either Class B or unclassified biosolids, with only a few facilities producing Exceptional Quality or Class A biosolids.

The City's biosolids are currently applied at either the Hauser and Hauser site or at the Orme Ranch site. However, there are other registered land application sites within a similar distance from Prescott. In the short term, there are no apparent land availability issues for Class B biosolids produced from the City.

The future trend in land availability for Yavapai County is generally consistent with trends occurring in the State of Arizona, particularly in other Counties experiencing significant population growth. The statewide trend shows a reduction in farmland acreage. The rate (percentage) of farmland acreage loss in Yavapai County is significantly greater than the statewide trend, but similar to other fast-growing counties such as Maricopa County and Yuma County.

In general, there are no indications in the short-term that would indicate an urgent need to take the existing level of biosolids treatment beyond Class B quality. In the long-term, production of Exceptional Quality or Class A biosolids can provide an improved degree of flexibility for biosolids disposal given the trends of reduced availability of cropland areas and increased concerns from the general public. However, a detailed analysis of disposal alternatives is recommended before embarking on investments towards the production of Class A or Exceptional Quality biosolids, in order to analyze the cost-benefits of the increased level of biosolids treatment.

There are no regulatory issues in the horizon that would significantly affect biosolids management in the short and medium term. However, the potential risks posed by of micro constituents and emerging contaminants are currently being evaluated at the research level.

ES9 TM 9 – BIOSOLIDS ALTERNATIVES EVALUATION

ES9.1 Introduction

The long-term capital improvements identified for the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF) include the expansion of the treatment facilities and supporting infrastructure. These expansions will result in the generation of additional biosolids requiring treatment and disposal. The increased quantities of biosolids will present new biosolids treatment and disposal challenges, which will directly impact treatment plant operations and budgeting efforts. The City has recognized the need to review and evaluate their approach to biosolids management procedures to provide a framework for future treatment and disposal practices. Furthermore, the instability in legislation and market changes associated with biosolids necessitate the identification of appropriate alternatives to maximize the City's biosolids treatment and disposal flexibility in the future.

Technical Memorandum (TM) No. 9 is part of the Sundog WWTP and Airport WRF Capacity and Technology Master Plan, and addresses Task Group 1200 – Biosolids Alternatives Evaluation.

The main purposes of this TM No. 9 are:

- To review available biosolids disposal and reuse alternatives and recommend near-term and long-term disposal alternatives.
- To review and screen available biosolids stabilization alternatives, in order to select alternatives for detailed evaluation.
- To determine the facilities required for the recommended biosolids stabilization alternatives.
- To evaluate biosolids management alternatives at separate wastewater treatment facilities versus all biosolids management at a centralized treatment plant.
- To evaluate alternatives for biogas utilization.
- To perform a detailed evaluation of economic and non-economic factors for the biosolids management alternatives considered.

ES9.2 Biosolids Disposal and Reuse Alternatives

Ultimately, the desired biosolids disposal and reuse options play a significant role in the selection of the sludge stabilization processes (i.e., EQ versus Class A versus Class B) and the subsequent solids handling facilities.

The goal of this biosolids alternatives evaluation is to determine disposal options, which provide flexibility, redundancy, and the ability to meet current and future regulatory criteria. As mentioned previously, there are currently no formal restrictions for the land application of biosolids in the State of Arizona. Even though a number of counties in California have implemented full or partial bans of Class B biosolids land application and/or restrictions on the use of EQ and Class A biosolids, it is difficult to predict whether or not such restrictions would ever be imposed in Arizona.

As stated in TM No. 8, there are no clear indications that Class B land application would be restricted for the City of Prescott in the foreseeable future. Therefore, we recommend master planning biosolids treatment facilities based on achieving Class B, with considerations to achieve Class A in the future.

The following Table ES9.1 summarizes the options for biosolids disposal evaluated as part of this TM.

Table ES9.1 Biosolids Disposal Alternatives Summary
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Disposal/Beneficial Reuse Alternative	Minimum Biosolids Criteria					
	EQ	Class A	Class B	Liquid	Dewatered	Dry Pellets
Land Application - Agricultural Land			X	X		
Land Application - City-owned Land(1)	X	X			X	X
Landfill Disposal(2)					X	
Commercial Product	X	X				X

Notes:
(1) Will depend on requirements of the City Parks and Recreation and Transportation Departments.
(2) Landfill disposal requires dewatering to level capable of passing the Paint Filter Test. Class B, A, or EQ can also be disposed of in landfills.

The most cost-effective and practical strategy would be for the City to continue its practice of land applying Class B biosolids from the Sundog WWTP on agricultural land, and to continue landfill disposal of biosolids from the Airport WRF until biosolids stabilization facilities can be constructed. However, landfill disposal is not recommended as a long-term alternative, as available landfill space is generally limited. Therefore, the City should plan to implement improvements at the existing Airport WRF to produce Class B biosolids when this alternative becomes economically viable. Ultimately, upgrading the stabilization processes to achieve EQ or Class A biosolids should be considered, in order to maintain the greatest flexibility with future biosolids disposal alternatives.

ES9.3 Biosolids Stabilization

The City's existing WWTPs are currently equipped with processes capable of reliably producing Class B biosolids (Sundog WWTP) or unclassified biosolids (Airport WRF), which limits available biosolids management alternatives to agricultural farmland sites and landfill disposal. Although these management strategies are sufficient and generally considered to be the most cost effective in the near- and long-term, changing regulations and decreasing availability of agricultural lands may limit opportunities for land apply and landfill in the future. As a result, the City may have to consider higher levels of treatment for biosolids production in the future, and consequently would have to add technologies (i.e. additional equipment and facilities) to the current processes in order to produce EQ or Class A biosolids.

After initial process screening, the following stabilization processes were evaluated for the Sundog WWTP and the Airport WRF as separate treatment facilities, or a centralized Airport WRF:

- Conventional Anaerobic Digestion
- Thermal Drying

The capital costs and operating costs for anaerobic digestion and thermal drying at the Sundog WWTP, Airport WRF, and the Centralized Airport WRF are provided in Tables ES9.2, ES9.3, and ES9.4 below. For all cases, anaerobic digestion is the preferred economic alternative.

Table ES9.2 Stabilization Capital and Operating Costs – Sundog WWTP
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Criteria	Anaerobic Digestion	Thermal Drying
Probable Construction Cost	$5,426,000	$14,000,000
Annual O&M Costs	$340,100	$1,220,000
Total Life-Cycle Cost	$10,099,000	$27,990,000

Note:
(1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.

Table ES9.3 Stabilization Capital and Operating Costs – Airport WRF Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Criteria	**Anaerobic Digestion**	**Thermal Drying**
Probable Construction Cost	$22,680,000	$21,700,000
Annual O&M Costs	$544,600	$2,192,000
Total Life-Cycle Cost	$30,163,000	$46,840,000
Note: (1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.		

Table ES9.4 Stabilization Capital/Operating Costs - Centralized Airport WRF Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Criteria	**Anaerobic Digestion**	**Thermal Drying**
Probable Construction Cost	$25,760,000	$35,700,000
Annual O&M Costs	$732,000	$3,362,000
Total Life-Cycle Cost	$35,818,000	$75,250,000
Note: (1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.		

While anaerobic digesters are preferred from an economic standpoint, thermal dryers will produce a fertilizer product that has agricultural and recycling value, whereas dewatered anaerobic sludge has little value and in many jurisdictions has become a liability for municipal agencies. Given a long term view of biosolids disposal, the City of Prescott should consider thermal drying of biosolids in a central treatment facility as flows increase and new residential construction re-starts.

In considering a regional biosolids treatment facility, the following alternatives were identified for future consideration:

- Composting
- Thermal drying
- Biosolids to Energy (Incineration)

ES9.4 Biogas Utilization

As part of the biosolids master planning tasks, biogas utilization options for the Sundog WWTP and the regional treatment facility alternative at Airport WRF were evaluated. The biogas utilization options considered in this evaluation include process heating and on-site power generation. Economic and non-economic considerations and life cycle costing were used to evaluate potential biogas utilization alternatives.

Biogas produced through anaerobic digestion is a prime source of energy that is traditionally used for process heat (digestion and/or heat drying), building heat, or to generate power. Heat recovery from on-site power generation or drying can also be employed to heat digesters and buildings. The costs and benefits of biogas utilization vary depending on capacity requirements, purchased energy costs, biogas cleaning requirements, and process heat requirements. Three biogas utilization options were short-listed for detailed evaluation for each treatment facility, as follows:

1. Biogas use for process (anaerobic digester) heat.
2. Biogas use in engine generators for on-site power generation and waste heat recovery.
3. Biogas use in MicroTurbines for on-site power generation and waste heat recovery.

Equipment requirements and costs were developed for each alternative at both the Sundog WWTP and the centralized treatment facility at the Airport WRF. In addition, costs were developed for a “base case” scenario. The “base case” scenario represents no energy recovery and flaring of all biogas. Natural gas must be purchased for digester heating in the “base case” scenario.

Descriptions of each evaluated alternative for power generation and energy recovery are presented below:

- Case 1 - All biogas to the boiler for digester heating. Excess biogas is flared. This configuration is widely used at WWTPs equipped with anaerobic digestion.
- Case 2 - All gas to engine generators. Heat recovered from the engine generator jackets and exhaust is used for digester heating.
- Case 3 - All gas to MicroTurbines. Heat recovered from the MicroTurbine exhaust is used for digester heating.

Sundog WWTP

The following Table ES9.5 summarizes the cost or savings associated with each scenario described above for the Sundog WWTP.

Table ES9.5 Costs and Benefits for Digester Gas Utilization at Sundog WWTP Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
	Case 1 **Digester Heat**	**Case 2** **Engine Generators**	**Case 3** **MicroTurbines**
Capital Cost, $			
Energy recovery	0	337,000	532,000
Gas cleaning	200,000	693,000	808,000
Total	200,000	1,030,000	1,340,000
Annual Costs for Energy Recovery, $/year			
Electricity	0	0	0
Labor	0	21,000	19,000
Maintenance materials	0	16,000	6,000
Total	0	37,000	25,000
Annual Costs for Gas Cleaning, $/year			
Electricity	13,000	14,000	24,000
Labor	6,000	23,000	23,000
Maintenance materials	1,000	18,000	18,000
Total	20,000	55,000	65,000
Annual Benefits, $/year			
Electricity (Savings)	0	(89,000)	(66,000)
Natural Gas (Savings)	(33,000)	(33,000)	(32,000)
Present Worth Costs, $			
Capital Costs	200,000	1,030,000	1,340,000
Annual Costs	20,000	92,000	90,000
Annual (Savings)	(33,000)	(122,000)	(98,000)
Total Annual Cost (Savings)	(13,000)	(30,000)	(8,000)
PW Annual Cost (Savings)	(162,000)	(374,000)	(100,000)
PW Total Cost (Savings)	38,000	656,000	1,240,000
Annualized PW Cost	3,000	53,000	100,000

Life cycle costs evaluation for the Sundog WWTP shows that the total present worth cost of the three biogas utilization alternatives are $38,000, $656,000, and $1,240,000, respectively, meaning that no cost savings are projected. Based on the results of this evaluation, on-site power generation is not cost effective and is therefore not recommended for the Sundog WWTP. However, use of biogas for digester heating eliminates the need for natural gas purchases and consequently, the impacts of fluctuating natural gas prices on plant O&M costs. There is considerable potential savings with this approach, particularly if biogas treatment is not required. In fact, the City reports that by switching to untreated digester gas for sludge heating, they are currently saving about $63,000 per year.

Centralized Airport WRF

Table ES9.6 summarizes the cost benefits of each scenario described above for a Centralized Airport WRF.

Table ES9.6 Costs and Benefits for Digester Gas Utilization at Centralized Airport WRF
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Case 1 Digester Heat	Case 2 Engine Generators	Case 3 MicroTurbines
Capital Cost, $			
Energy recovery	0	676,000	8611,000
Gas cleaning	530,000	894,000	1,049,000
Total	530,000	1,570,000	1,860,000
Annual Costs for Energy Recovery, $/year			
Electricity	0	0	0
Labor	0	25,000	20,000
Maintenance materials	0	35,000	14,000
Total	0	60,000	34,000
Annual Costs for Gas Cleaning, $/year			
Electricity	14,000	16,000	28,000
Labor	6,000	23,000	23,000
Maintenance materials	2,000	36,000	37,000
Total	22,000	75,000	88,000
Annual Benefits, $/year			
Electricity	0	(200,000)	(148,000)
Natural Gas Savings	(74,000)	(74,000)	(71,000)
Present Worth Costs, $			
Capital Costs	530,000	1,570,000	1,860,000
Annual Costs	22,000	135,000	125,000
Annual Savings	(74,000)	(274,000)	(219,000)
Total Annual Cost (Savings)	(52,000)	(139,000)	(97,000)
PW Annual Cost (Savings)	(648,000)	(1,732,000)	(1,208,000)
PW Total Cost (Savings)	(118,000)	(162,000)	652,000
Annualized PW (Savings)	(9,000)	(13,000)	52,000

Based on the lifecycle costs of the gas utilization options at the Centralized Airport WRF, on-site power generation using engine generators may be cost effective. As shown in Table ES9.6, the present worth savings for the Cases 1 and 2 are $118,000 and $162,000 respectively, and the present worth cost for Case 3 is $652,000. Based on the results of this evaluation, on-site power generation using engine generators is recommended for future consideration at a Centralized Airport WRF when the capital cost of the facilities is not constrained by funds availability in the City's CIP. If future emission restrictions at the Centralized Airport WRF require advanced emission control for engine generators, Case 2 capital and O&M costs will increase significantly and the evaluation should be revisited.

ES9.5 Regional Biosolids Management

As part of this project, the team discussed the possibilities/opportunities for a regional biosolids handling facility, which could process and provide beneficial end use of biosolids from a variety of surrounding communities, including the City of Prescott. In the context of a larger regional facility, the potential application of certain technologies becomes significantly more viable as capital and O&M costs can be partially offset by factors including economies of scale and cogeneration opportunities.

Contributing communities could share the fiscal responsibility for construction and operation, thereby reducing the burden on the individual communities. In addition, the resulting high quality biosolids could be redistributed within the participating communities on community-owned parks and golf courses, or could potentially be marketed to outside agencies or the general public - providing a sustainable market for the beneficial end use product. Based on these factors, the possibility of a regional biosolids handling facility was evaluated, on a cursory level, as a potential long-term biosolids management strategy.

The successful implementation of a regional biosolids handling facility would depend heavily on the collaboration of various organizations, governing authorities, and local communities. Each group would play a significant role in the coordination of the project. Currently four of the local communities outside of Prescott have expressed interest in a regional biosolids handling facility project. Without the commitment of a majority of the communities to treat their undigested sludge at the regional facility, implementation of the facility may not be economically justifiable. Table ES9.7 provides a summary of the various communities contacted during this evaluation, their current and anticipated solids production as well as the general interest in a regional facility.

Table ES9.7 Summary of Potential Regional Facility Community Participants Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona

Community	Current Biosolids Management Practice	Current Biosolids Production (wet tons/ year)	Estimated Future Biosolids Production (wet tons/year)	Potential Interest in Regional Facility?
City of Flagstaff	Subsurface injection Class B biosolids	1,000 (1)	N.A.	Yes
City of Sedona	Landfill dewatered sludge	1,500	2,500	Yes
Town of Prescott Valley	Landfill Class B biosolids	4,500 - 5,000	15,000	Yes
Town of Camp Verde	Landfill dewatered sludge	N.A.	N.A.	Yes
Town of Chino Valley	Landfill dewatered sludge	274	1,100	N.A.
Town of Clarkdale	Landfill disposal of lagoon sludge	N.A.	N.A.	N.A.
City of Prescott	Land application Class B biosolids, and landfill dewatered sludge	4,490	21,800	Yes

Notes:
(1) To be confirmed
N.A. = Not available at the time the report was issued.

ES9.6 Conclusions

ES9.6.1 Biosolids Disposal and Reuse

The City currently practices land application on agricultural land with Class B biosolids from the Sundog WWTP. Unclassified biosolids from the Airport WRF are currently disposed of at a landfill. Maintaining these disposal and reuse practices represents the most cost-effective near-term strategy for the City. In the long-term, landfill disposal costs may increase and it will likely be cost effective to implement Class B biosolids stabilization facilities at the Airport WRF. If hauling costs increase dramatically, alternatives that significantly reduce the volume for disposal/reuse, such as thermal drying or biosolids-to-energy may become viable.

ES9.6.2 Biosolids Stabilization

For the near-term and long-term, continued anaerobic digestion is recommended for the Sundog WWTP. At the Airport WRF, continued dewatering and hauling of non-stabilized solids is recommended in the near-term. As the Airport WRF grows in size (5-10 mgd) and the costs for landfilling of unclassified biosolids increases, it is recommended that the City implement anaerobic digestion for Class B biosolids stabilization. If centralized treatment at the Airport WRF is implemented, anaerobic digestion is recommended for the near-term and long-term to achieve Class B biosolids. Should a regional biosolids facility becomes a reality, alternatives to achieve Class A biosolids such as composting, thermal drying, and biosolids-to-energy should be evaluated.

ES9.6.3 Biogas Utilization

Continued use of biogas for digester heating at the Sundog WWTP is recommended. The City reports that they are saving approximately $63,000 per year in operating costs by eliminating natural gas heating of the digesters. Currently, on-site power generation is not cost-effective at the Sundog WWTP, unless grants or subsidies are available. If centralized treatment at the Airport WRF is implemented, on-site power generation will likely be cost effective when the treatment plant wastewater flow reaches approximately 5 mgd. Finally, if electrical power costs increase significantly, on-site power generation should be further evaluated for the Sundog WWTP or the Airport WRF (when anaerobic digestion is implemented at that facility).

ES9.6.4 Regional Biosolids Management

There does not appear to be an immediate opportunity for regional biosolids management given the need for significant collaboration between multiple organizations. The City should maintain contact with potential partners in the region, to determine if a regional biosolids facility would be practical and economical in the long-term. There may also be potential public-private partnership opportunities in the future with a regional solution to biosolids management.

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Introduction

Final

In Association with

Project No. 164890

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INTRODUCTION

1.0 BACKGROUND

Black & Veatch in association with Carollo Engineers was retained by the City of Prescott to perform a master plan for wastewater treatment facilities at the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF). The scope of work was segmented into four major task groups, as follows:

Part 1 – Sundog WWTP and Airport WRF capacity and Treatment Technology Master Plan

Part 2 – Airport WRF New-Term Improvements Design

Part 3 – Sundog WWTP and Airport WRF Biosolids Master Plan

Part 4 – Technically Based Local Limits Study

This document presents the results of Parts 1 and 3. The Local Limits Study (Part 4) is submitted as a separate deliverable. Part 2 will not be undertaken as the master plan recommendation is to replace the existing Airport WRF with a new facility negating the need for existing facility near term improvements.

The Technically Based Limits Study is an update of the City's current local limits used in its individual pretreatment program. USEPA 2004 Local Limits Guidance was used in the development of the industrial discharge limits. The preliminary industrial discharge limits for metals were established using the Allowable Headworks Loading Method recommended by USEPA which incorporates applicable environmental criteria, including permit limits, and biosolids disposal requirements.

The Technically Based local Limits Study is submitted as a separate document.

2.0 TREATMENT CAPACITY AND TECHNOLOGY MASTER PLAN GOALS AND OBJECTIVES

The wastewater treatment plant master plan effort was undertaken to provide:

- A comprehensive review of the existing facilities, including current influent loading.
- Establish current treatment capabilities.

- Review current regulatory requirements
- Project future treatment needs; evaluate alternative liquid treatment technologies.
- Investigate biogas renewable energy opportunities.
- Provide recommendations for needed expansions and upgrades.
- Provide conservative preliminary cost estimates for the City's use in preparing capital improvement cut budgets for recommended improvement.
- Evaluate biosolids management and disposal alternatives.
- Assess interest amongst Northern Arizona communities in a regional biosolids facilities.

Additional local limits study was conducted to establish industrial pretreatment requirements in accordance with federal regulations. The pretreatment study was submitted as a separate document.

3.0 MASTER PLAN FORMAT

The master plan was conducted as a series of technical memorandum (TMs). Following this introduction the master plan is presented as a compilation of the following TMs.

Technical Memorandum No. 1 – Regulatory, Compatibility, and Reliability Requirements

Technical Memorandum No. 2 – Control System Standards

Technical Memorandum No. 3S – Sundog WWTP Existing Conditions

Technical Memorandum No. 3A – Airport WRF Existing Conditions

Technical Memorandum No. 4 – Flow / Load Projections

Technical Memorandum No. 5S – Sundog WWTP Alternative Treatment Technologies

Technical Memorandum No. 5A – Airport WRF Alternative Treatment Technologies

Technical Memorandum No. 6 – Airport WRF Centralized Treatment Feasibility Analysis

Technical Memorandum No. 7 – Tertiary Filtration Evaluation

Technical Memorandum No. 8 – Biosolids Planning Conditions

Technical Memorandum No. 9 – Biosolids Alternatives Evaluation

4.0 EXISTING WASTEWATER TREATMENT FACILITIES OVERVIEW

Prescott operates two wastewater treatment / reclamation plants, as shown on Figure 1. The Sundog WWTP currently receives the majority of wastewater from downtown and the more established areas of Prescott. The Airport WRF serves newer developed areas to the north and northwest. Effluent produced in excess of the irrigation demand is recharged in percolation ponds near the Airport WRF to establish artificial recharge credits in the underlying aquifer.

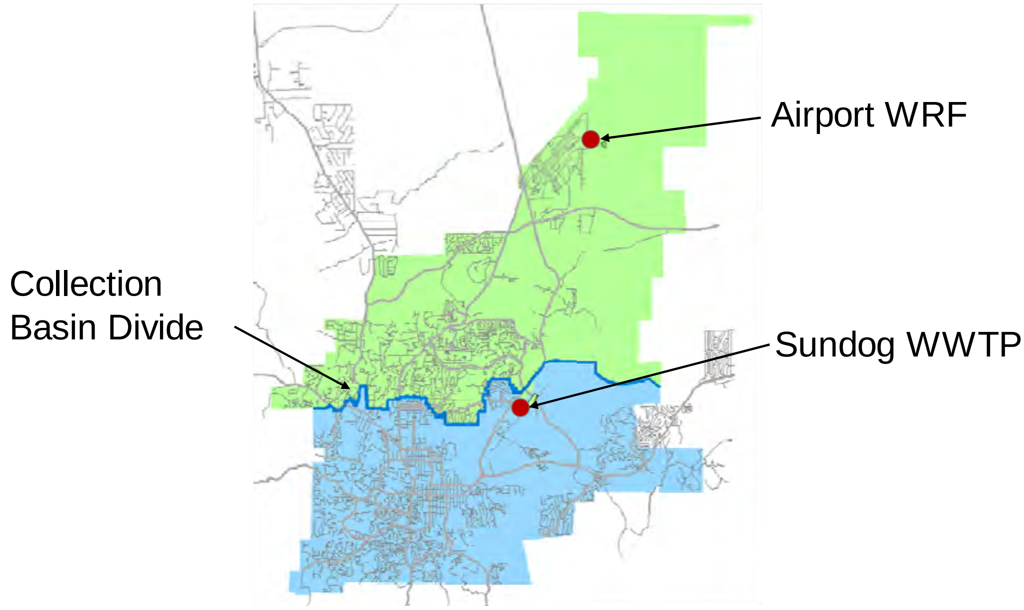

Figure 1 Sundog WWTP and Airport WRF Location and Service Areas

4.1 Plant Histories

The Sundog WWTP was originally constructed as an extended aeration oxidation ditch plant with an average annual capacity of 1.7 mgd. The plant treatment was later modified in 1989 to a conventional high rate activated sludge process with addition of anoxic zones for biological nitrogen removal. Anaerobic digesters were also added for sludge stabilization and the design plant capacity was increased to 6.0 mgd of average annual treatment capacity. The City later added a belt press in a temporary building for mechanical sludge dewatering to replace solar drying on sludge drying beds.

The Airport WRF was originally constructed as an extended aeration oxidation ditch facility. The process was modified in to a high rate activated sludge process with incorporation of anoxic and oxic zones for biological nitrogen removal.

A more detailed description of the existing facilities at each plant are presented in TM 3S for the Sundog WWTP and TM 3A for the Airport WRF. An assessment for treatment capacity based on current influent conditions are included.

5.0 COORDINATION WITH PREVIOUS STUDIES

Prior to this Wastewater Treatment Capacity and Technology Master Plan, Prescott commissioned the completion of a comprehensive water distribution and wastewater collection master plan. That effort included projections of future population growth and wastewater flows tributary to each of the wastewater treatment plants. The projections developed in the previous master plan are used for treatment plant recommendations developed in this treatment capacity and technology master plan.

The previous master plan also identified infiltration and inflow as a major source of peak flows in the wastewater collection system and the general areas of highest concern. Managing peak storm water flows at the treatment plants is a major issue. Assessment of storm related infiltration and inflow and associated facility recommendations are presented in TM 4.

6.0 BASIS OF COST ESTIMATING

Cost estimates are a critical component of the master plan for 1) comparing various alternatives and 2) providing the City with estimates to be used for budgeting recommended improvements. Cost estimates for master plans is challenging. The goal is to provide estimates that are as accurate as possible without the benefit of design definition for the recommendations. In general, our goal is to provide conservative estimates supported by industry accepted techniques for master planning estimates.

6.1 Estimating Accuracy

The level of accuracy for construction cost estimates varies depending on the level of detail to which the project has been defined. Feasibility studies and master plans represent the lowest level of accuracy, while pre-bid estimates (based on detailed plans and specifications) represent the highest level. The American Association of Cost Engineers (AACE) has developed the following guidelines for the various types of estimates.

Type of Estimate	Estimate Class	Anticipated Accuracy
Order-of-Magnitude *(Feasibility Study)*	5	+50% to -30%
Budgetary Estimate *(Predesign Report)*	3, 4	+30% to -15%
Definitive Estimate *(Pre-Bid)*	1, 2	+15% to -5%

The anticipated total construction costs presented this Wastewater treatment Capacity and Technology Master Plan should be considered a budgetary estimate level of accuracy, and are Class 4 according to AACE cost estimate classification definitions.

6.1.1 Capital Costs

The total estimated construction costs presented herein are based on cost information for similar projects in the state of Arizona, budgetary quotes for some of the major equipment, and take-offs for major structures. Cost information obtained from previous reference projects was escalated to April 2010 using the Engineering News Record (ENR) Construction cost Index (CCI) for the 20-Cities Average, based on the reported April 2010 CCI value of 8677.

The estimated construction costs were estimated adding 20 percent contingency, general contractor overhead, profit and risk fees at 15 percent, and sales tax at 5.0 percent of the total direct cost. No adjustment to mid-point of construction has been considered due to the uncertainly of the timing for improvements.

6.1.2 Operations and Maintenance Costs

Operations and maintenance costs were based on estimated costs for power consumption, chemical usage and labor requirements. Power consumption estimates were based on process operation at annual average day conditions, with estimated equipment horsepower and assumed efficiencies. Chemical usage was based on typical usage at similar-sized facilities. Labor requirements were estimated based on the "The Northeast Guide for Estimating Staffing at Publicly and Privately Owned Wastewater Treatment Plants" (New England Interstate Water Pollution Control Commission, November 2008), and adjusted for staffing in similar-sized facilities and staffing levels at the City's treatment facilities.

6.2 Conservative Technology Selections

Selection of some specific treatment technologies is beyond the scope of this master plan and it is more appropriate to provide a detailed evaluation for selection during preliminary design. Examples are the specific technology recommended for plant disinfection and solids dewatering. Where several technologies are available, our approach to developing treatment plant cost estimates is to present the alternatives, select the higher cost alternative to be conservative and recommend further study during for those components during detailed design.

Examples are the specific technology recommended for plant disinfection and solids dewatering. Where several technologies are available, our approach to developing treatment plant cost estimates is to present the alternatives, select the higher cost alternatives to be conservative and recommend further study for those components during detailed design.

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 1
Regulatory, Compatibility and
Reliability Requirements

Final

In Association with

Project No. 164890

3033 NORTH 44TH STREET • SUITE 101 • PHOENIX, ARIZONA 85018 • (602) 263-9500 • FAX (602) 265-1422

City of Prescott

TECHNICAL MEMORANDUM
NO. 1
REGULATORY/COMPATIBILITY/RELIABILITY REQUIREMENTS

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ES1 TM 1 – REGULATORY, COMPATIBILITY AND RELIABILITY REQUIREMENTS

ES1.1 Introduction

Existing and future regulatory requirements affect the planning and design of future treatment facilities at the Sundog WWTP and Airport WRF. An analysis of regulatory and reliability requirements was performed for aspects that included effluent quality, odor control, and process redundancy, as well as potential future regulatory requirements on emerging issues related to liquids treatment.

ES1.2 Existing Effluent Quality Requirements

Current discharge permit limits are summarized in Table ES1.1.

The City is currently reusing and/or recharging (depending on seasonal irrigation usage) all of its reclaimed water. If the City ever considers surface water discharge as an effluent disposal method, an AZPDES permit would be required, and the numerical standards associated with the surface water discharge regulations would need to be further evaluated.

Table ES1.1 Current Discharge Permit Limits Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements City of Prescott, Arizona		
Criteria	**Sundog WWTP (1)**	**Airport WRF (2)**
Flow, mgd		
Average monthly	6.0	2.2 (3)
Daily	Not established	Not established
Effluent Quality Classification	Class B+	Class B+
Total Nitrogen, mg/L		
Maximum limit (4)	10	10
Alert level	8	8
Turbidity, NTU	N.A.	N.A.
Fecal Coliform, cfu/100 mL		
Four of last seven samples	200	200
Single sample maximum	800	800

Notes:
(1) Amendment to Aquifer Protection Permit No. P-100353, LTF No. 22654, August 19, 2002.
(2) Amendment to Aquifer Protection Permit No. P-101733, LTF 46504, August 18, 2009.
(3) The infiltration basins at the Airport WRF are permitted for a maximum monthly average flow of 4.4 mgd, combined from both facilities.
(4) Based on a 5-month geometric mean of the results of the 5 most recent samples.

ES1.3 Water Quality Standards and Regulatory Requirements

Any significant major expansion at the Sundog WWTP and the Airport WRF will require compliance with ADEQ Best Available Demonstrated Technologies (BADCT) requirements. The technology assessment performed for this master plan considered technologies that are capable of achieving the minimum effluent water quality parameters specified per BADCT standards.

Table ES1.2 summarizes the different requirements for Class A+, B+, and C quality reclaimed water. It is important to note that BADCT disinfection requirements are essentially equivalent to the Class A+ quality requirements for new or expanded facilities with design flows above 250,000 gpd, such as the Sundog WWTP and the Airport WRF.

Table ES1.2	ADEQ Reclaimed Water Quality Standards Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements City of Prescott, Arizona		
	Effluent Limits		
Parameter	**Class A+ [1]**	**Class B+ [2]**	**Class C [3]**
Secondary treatment	X	X	Stabilization ponds with 20-day detention
Filtration	X	NR	NR
Denitrification	X	X	NR
Disinfection	X	X	With or without
Total Nitrogen (as N) [4]	< 10 mg/L	< 10 mg/L	N/A
Turbidity			
Daily (24-hour) average	2 NTU	N/A	N/A
Single sample maximum	5 NTU	N/A	N/A
Fecal Coliform			
Single sample maximum	23 cfu/100 mL	800 cfu/100 mL	4,000 cfu/100 mL
Four out of last seven daily samples	None detect	200 cfu/100 mL	1,000 cfu/100 mL

Notes:
X = Requirement
NR = Not Requirement
(1) Reference: A.A.C. R-18-11-303
(2) Reference: A.A.C. R-18-11-305
(3) Reference: A.A.C. R-18-11-307
(4) Five sample geometric mean

Total trihalomethanes (TTHMs) are disinfection byproducts associated with the use of chlorine. There is no current numerical standard for TTHMs in Arizona for reuse, even though BADCT and Class A+ Reuse Rules both require minimization of TTHMs. For recharge, the A.A.C. requires that any water discharged to a drinking water aquifer must meet the drinking water quality standards. Therefore, a TTHM level of 80 µg/L (Stage 2 Disinfection / Disinfection By-Product Rules) applies to the recharge water.

Endocrine disruptors, pharmaceuticals, and personal care products are contaminants that could be regulated in the future. It is too early in the regulatory process to determine which contaminants may be regulated and to what level. However, the City should be aware of these contaminants and understand the impacts of possible future regulations.

Salt build-up in some areas of Arizona (such as the Phoenix metropolitan area) is a growing concern. Salt levels become more concentrated as water is used and reclaimed. Because the potential for reuse opportunities of reclaimed water diminishes (especially for irrigation uses) as salt concentrations rise, it is important to recognize the importance of controlling salt build-up in the future.

ES1.4 Odor and Noise Control

BADCT requirements establish that minimum setbacks must be maintained for water reclamation facilities. A setback of 1,000 feet should be maintained if no odor, noise or aesthetic controls are provided. A setback of 350 feet should be maintained if full noise, odor, and aesthetic controls are provided. These setbacks can be decreased if allowed by local ordinances, or if waivers are obtained from affected property owners.

Odor control measures will likely be required at both facilities per BADCT requirements. The majority of the odors originate from headworks, primary sedimentation, and solids handling processes, and special emphasis should be placed in providing odor control for those facilities in future plant expansions and improvements.

ES1.5 Reliability Requirements

Reliability and redundancy in the treatment process should be included in future designs, in order to provide the ability to comply with the required effluent quality goals even at times when process units are temporarily taken out of service for maintenance or repair.

1.0 INTRODUCTION

This technical memorandum is part of the Master Planning, Design, and Local Limits project for the City of Prescott Airport Wastewater Reclamation Facility (WRF) and Sundog Wastewater Treatment Plant (WWTP). Technical Memorandum (TM) No. 1 addresses Task Group 200 - Regulatory / Compatibility / Reliability Requirements, with the exception of Task 204 (SCADA requirements), which is addressed in a separate Technical Memorandum.

The main objectives of TM No. 1 are:

- To summarize the existing Aquifer Protection Permits at the Airport WRF and the Sundog WWTP to establish the current effluent quality requirements;
- To review water reuse and recharge regulatory trends, in order to identify potential future requirements at the City's wastewater treatment facilities;
- To review and summarize regulatory requirements for odor control, in order to identify future requirements at the City's wastewater treatment facilities; and
- To summarize process redundancy requirements, including standby power as well as unit process redundancy.

1.1 Reference Documents

The following reference documents were used for the preparation of this Technical Memorandum No. 1:

- Sundog WWTP Aquifer Protection Permit. Amendment to Aquifer Protection Permit No. P-100353, LTF No. 22654, August 19, 2002.
- Airport WRF and Recharge Basins Aquifer Protection Permit. Amendment to APP, LTF 46504, August 18, 2009.
- Arizona Administrative Code, Title 18 - Environmental Quality. Chapter 9, Supplement 05-3. Chapter 11, Supplement 03-1. State of Arizona.
- Engineering Bulletin No. 11 - Minimum Requirements for Design, Submission of Plans and Specifications of Sewage Works, Arizona Department of Environmental Quality, July 1978.
- Recommended Standards for Wastewater Facilities, Wastewater Committee of the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2004 Edition.
- Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, Second Edition. National Water Research Institute and Awwa Research Foundation, May 2003.
- Guidelines for Water Reuse, United States Environmental Protection Agency, September 2004.

2.0 EXISTING EFFLUENT QUALITY REQUIREMENTS

The Sundog WWTP currently has a permitted capacity of 6.0 million gallons per day (mgd) monthly average flow. The Airport WRF currently has a permitted capacity of 2.2 mgd monthly average flow. The recharge basins at the Airport WRF site are permitted to receive effluent from both the Airport WRF and the Sundog WWTP, with a maximum permitted capacity of 4.4 mgd as a monthly average flow combined from the two facilities.

The Sundog WWTP and the Airport WRF are currently permitted to produce Class B+ quality effluent, according to their current Aquifer Protection Permits (APP), issued by the Arizona Department of Environmental Quality (ADEQ). The most recent amendment to the current APP for the Airport WRF was signed on August 18, 2009, and includes the recent replacement of the belt filter press sludge dewatering system with a centrifuge sludge dewatering system. The most recent amendment to the Sundog WWTP APP was completed in 2002. Effluent from both facilities is currently being recharged into the aquifer and/or reused per applicable Class B+ uses such as golf course irrigation and construction materials washing. The permit requirements for both facilities are summarized in Table 1.1.

Table 1.1 Current Discharge Permit Limits
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

Criteria	Sundog WWTP (1)	Airport WRF (2)
Flow, mgd		
Average monthly	6.0	2.2 (3)
Daily	Not established	Not established
Effluent Quality Classification	Class B+	Class B+
Total Nitrogen, mg/L		
Maximum limit (4)	10	10
Alert level	8	8
Turbidity, NTU	N.A.	N.A.
Fecal Coliform, cfu/100 mL		
Four of last seven samples	200	200
Single sample maximum	800	800

Notes:
(1) Amendment to Aquifer Protection Permit No. P-100353, LTF No. 22654, August 19, 2002.
(2) Amendment to Aquifer Protection Permit No. P-101733, LTF 46504, August 18, 2009.
(3) The infiltration basins at the Airport WRF are permitted for a maximum monthly average flow of 4.4 mgd, combined from both facilities.
(4) Based on a 5-month geometric mean of the results of the 5 most recent samples.

3.0 WATER QUALITY STANDARDS AND REGULATORY REQUIREMENTS

Water quality standards for reclaimed water depend on the intended use of the effluent of water reclamation facilities. The purpose of this section is to provide a general overview of the current regulatory environment, and to identify water quality requirements for future expansion at the Sundog WWTP and the Airport WRF.

3.1 National Pollutant Discharge Elimination System (NPDES) Program

The National Pollutant Discharge Elimination System (NPDES), established by USEPA, is a permitting program that establishes requirements for wastewater effluent discharge to water bodies. The NPDES is enforced through monitoring and reporting. NPDES permits are site-specific discharge standards that incorporate Federal Clean Water Act mandates and the State Surface Water Quality Standards. On December 5, 2002, Arizona became one of 45 states with authorization from EPA to operate the NPDES Permit Program (Section 402 of the Clean Water Act) on the state level.

Under the Arizona Pollutant Discharge Elimination System (AZPDES) Permit Program, all facilities that discharge pollutants from any point source into waters of the United States (navigable waters) are required to obtain or seek coverage under an AZPDES permit. Pollutants can enter waters of the United States from a variety of pathways, including agricultural, domestic, and industrial sources. For regulatory purposes, these sources are generally categorized as either point source or non-point sources. ADEQ developed rules for the AZPDES program in 2001, and revised them in 2002 and 2004. The most recent revision was published in the Arizona Administrative Code (A.A.C.) on December 26, 2003, with an effective date of February 4, 2004.

ADEQ recently completed a triennial review of surface water quality standards. ADEQ submitted a Notice of Final Rulemaking for Surface Water Quality Standards to the Governor's Regulatory Review Council (GRCC) in December 2008, and was published in the Arizona Administrative Register (A.A.R.), Volume 14, Issue 52.

A.A.C. R-18-11 sets the numerical water quality standards for surface waters within the state. When discharging to surface waters, the applicable numerical standards apply depending on the specific conditions of the receiving water body. Among the many parameters listed in A.A.C. R-18-11, nutrients such as nitrogen (including ammonia) and phosphorous can significantly impact the treatment technology selection.

The City is currently reusing and/or recharging (depending on seasonal irrigation usage) all of its reclaimed water; therefore, the surface water quality standards requirements are currently not applied to the treatment plants discharge permits. If the City ever considers surface water discharge as an effluent disposal method, an AZPDES permit would be required, and the numerical standards associated with the surface water discharge would need to be met.

3.2 Federal Guidelines for Reclaimed Water Reuse

There are currently no federal regulations for reclaimed water reuse applications. In 2004, the USEPA suggested guidelines for reclaimed water quality standards for various reuse categories (*Guidelines for Water Reuse*, USEPA, September 2004). There is a tendency to use the Safe Drinking Water Act (SDWA) National Primary Drinking Water Regulations (NPDWRs) while defining requirements for reclaimed water that is used for potable reuse. Current drinking water standards, however, were developed based on freshwater sources, and were not based on municipal wastewater as a source. Furthermore, none of the emerging constituents of concern, including endocrine disruptors, pharmaceuticals, personal care products and hormones, are currently regulated by maximum contaminant levels in the SDWA.

3.3 Reclaimed Water Reuse Regulations in Other States

The USEPA published the *Guidelines for Water Reuse* in September of 2004. This comprehensive document presents a global perspective on water reuse practices and regulations across the Unites States, among other water reuse topics.

The leading states in terms of water reuse applications and regulations are Arizona, California, Colorado, Florida, Hawaii, Nevada, New Jersey, Oregon, Texas, Utah, and Washington. These states have extensive regulations or guidelines that prescribe requirements for a wide range of end uses of the reclaimed water. The reused water quality required in these states depends on the end use. End uses with a high risk of public exposure typically require a higher degree of treatment.

The main parameters regulated in water reuse applications include Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), turbidity, and coliform counts. Table 1.2 summarizes treatment requirements for unrestricted urban reuse in some of the states that lead the country in water reuse practices and regulations. Table 1.3 summarizes treatment requirements for restricted urban reuse. The comparison of the required qualities shows that some states apply more stringent water reuse standards for high-risk public exposure applications. A comparison of water reuse quality requirement for other end uses such as agricultural, recreational, industrial, and wetlands is also presented in the *Guidelines for Water Reuse* document (USEPA, 2004).

Table 1.2 Reused Water Quality Parameters for Unrestricted Urban Reuse
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

	Treatment [1]	BOD [1] (mg/L)	TSS [1] (mg/L)	Turbidity [1] (NTU)		Type	Coliform [1] (CFU/100 mL)	
Arizona	Secondary treatment, filtration and disinfection	N.S. [2]	N.S. [2]	2 (avg)	5 (max)	Fecal	Non detect (avg)	23 (max)
California	Oxidized, coagulated, filtered, and disinfected	N.S. [2]	N.S. [2]	2 (avg)	5 (max)	Total	2.2 (avg)	23 (max in 30 days)
Florida	Secondary treatment, filtration and high-level disinfection	20 ($CBOD_5$)	5.0	N.S. [2]		Fecal	75% of samples below detection	25 (max)
Hawaii	Oxidized, filtered, and disinfected	N.S. [2]	N.S. [2]	2 (max)		Fecal	2.2 (avg)	23 (max in 30 days)
Nevada	Secondary treatment, and disinfection	30	N.S. [2]	N.S. [2]		Fecal	2.2 (avg)	23 (max)
Texas	N.S. [2]	5	N.S. [2]	3		Fecal	20 (avg)	75 (max)
Washington	Oxidized, coagulated, filtered, and disinfected	30	30	2 (avg)	5 (max)	Total	2.2 (avg)	23 (max)

Notes:
(1) Information from *Guidelines for Water Reuse*, USEPA, September 2004.
(2) Not specified in state regulations.

Table 1.3 Reused Water Quality Parameters for Restricted Urban Reuse
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

	Treatment [1]	BOD [1] (mg/L)	TSS [1] (mg/L)	Turbidity [1] (NTU)		Type	Coliform [1] (CFU/100 mL)	
Arizona	Secondary treatment, and disinfection	N.S. [2]	N.S. [2]	N.S. [2]		Fecal	200 (avg)	800 (max)
California	Secondary - 23, oxidized, and disinfected	N.S. [2]	N.S. [2]	N.S. [2]		Total	23 (avg)	240 (max in 30 days)
Florida	Secondary treatment, filtration and high-level disinfection	20 ($CBOD_5$)	5.0	N.S. [2]		Fecal	75% of samples below detection	25 (max)
Hawaii	Oxidized and disinfected	N.S. [2]	N.S. [2]	2 (max)		Fecal	23 (avg)	200 (max)
Nevada	Secondary treatment and disinfection	30	N.S. [2]	N.S. [2]		Fecal	23 (avg)	240 (max)
Texas	N.S. [2]	20	N.S. [2]	3		Fecal	200 (avg)	800 (max)
Washington	Oxidized and disinfected	30	30	2 (avg)	5 (max)	Total	23 (avg)	240 (max)

Notes:
(1) Information from *Guidelines for Water Reuse*, USEPA, September 2004.
(2) Not specified in state regulations.

3.4 ADEQ BADCT Requirement

ADEQ sets forth the regulations pertaining to wastewater treatment effluent quality and effluent management in Arizona. The recent ADEQ rules require that wastewater treatment plants in the State of Arizona must meet the conditions of Best Available Demonstrated Control Technology (BADCT). Treated effluent must (at a minimum) meet or exceed the current standards set forth in the Arizona Administrative Code (A.A.C.), specifically as defined in A.A.C. R-18-9 and A.A.C. R-18-11. The BADCT treatment performance requirements are presented in Table 1.4.

Table 1.4 ADEQ BADCT Effluent Requirements
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

	Effluent Limits (1)	
Parameters	**Average Daily Flow <250,000 gpd**	**Average Daily Flow >250,000 gpd**
pH	6.0 - 9.0	6.0 - 9.0
BOD (30 day average)	< 30 mg/L	< 30 mg/L
BOD (7 day average)	< 45 mg/L	< 45 mg/L
TSS (30 day average)	< 30 mg/L	< 30 mg/L
TSS (7 day average)	< 45 mg/L	< 45 mg/L
Removal Efficiency for BOD, cBOD, TSS	85%	85%
Total Nitrogen (as N) (2)(3)	< 10 mg/L	< 10 mg/L
Fecal Coliform (3)		
Single sample maximum	800 cfu/100 mL	23 cfu/100 mL
Four of seven daily samples in one week	200 cfu/100 mL	Non detect
R18-11-406(B-G) constituents	Numeric water quality standards must be met	
A.R.S. 49-243(I) regulated chemicals	Removal to greatest extent possible without regard to cost	
Trihalomethanes	Minimize THM compounds generated as disinfection byproducts	

Notes:
(1) Reference: A.A.C. R-18-9-B204.
(2) Five-month rolling geometric mean.
(3) BADCT standards allow for soil aquifer treatment if it can be proven that the required level of treatment is reached prior to effluent interfacing with the groundwater.

BADCT requirements apply not only to new wastewater treatment plants, but also to wastewater treatment plants that undergo major modifications or expand their treatment capacity as defined in A.A.C. R-18-9-B206. There are two conditions that require an existing facility to comply with current BADCT requirements as presented in Table 1.:

- **An increase in the design flow.** The minimum design flow increase that triggers BADCT requirements depends on the permitted design flow of a wastewater treatment plant (A.A.C. R-18-9-A211). For the Sundog WWTP, a 4 percent increase in the design flow (flow above 6.24 mgd) will require compliance with current BADCT requirements. For the Airport WRF, compliance with current BADCT requirements is triggered with a 6 percent increase in the design flow (flow above 2.33 mgd).
- **Addition of major facilities.** Requirements in A.A.C. R-18-9-B206 state that "An addition of a physically separate process or major piece of production equipment, building, or structure that causes a separate discharge to the extent that the treatment performance requirements for the pollutants addressed in A.A.C. R-18-9-B204 can practicably be achieved by the addition." The pollutants in A.A.C. R-18-9-B204 were presented in Table 1.4.

Therefore, it is expected that any significant major expansion at the Sundog WWTP and the Airport WRF will require compliance with ADEQ BADCT requirements. The technology assessment performed under this project shall only consider technologies that are capable of achieving these minimum effluent parameters.

3.5 ADEQ Reuse Applications

The required quality of treated effluent is dependent on the intended end use of the reclaimed water. The ADEQ reuse regulations categorize reclaimed water into three main classes: A, B or C effluent. In addition, if nitrogen removal is provided, then the water can be classified as A+ or B+. A+ water essentially has unlimited options for water reuse applications (except for potable water supply), while B+, though unacceptable for use at schools, parks and recreational lakes, is adequate for golf courses, and other restricted-access landscape irrigation uses. Table 1.5 summarizes some of the acceptable reuse applications included in Table A of A.A.C. R-18-11.

Table 1.5 ADEQ Minimum Reclaimed Water Quality Requirements
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

Type of Direct Reuse [(1)]	Minimum Required Quality [(1)]
Irrigation of food crops	A
Residential / school ground landscape irrigation	A
Open-access landscape irrigation	A
Fire protection systems	A

Table 1.5	ADEQ Minimum Reclaimed Water Quality Requirements Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements City of Prescott, Arizona
Type of Direct Reuse (1)	**Minimum Required Quality (1)**
Vehicle and equipment washing	A
Golf course irrigation	B
Restricted-access landscape irrigation	B
Soil compaction and similar construction activities	B
Concrete and cement mixing	B
Materials washing and sieving	B

Note:
(1) Reference: A.A.C. R-18-11. Only a partial list is included.

The main difference between Class A+ and B+ reclaimed water quality, in terms of treatment requirements, is the level of tertiary filtration and disinfection required. Table 1.6 summarizes the different requirements for Class A+, B+, and C quality reclaimed water. It is important to note that BADCT requirements (Table 1.) are essentially equivalent to the Class A+ quality requirements for new or expanded facilities with design flows above 250,000 gpd, such as the Sundog WWTP and the Airport WRF.

3.6 Disinfection and Disinfection Byproduct Requirements

3.6.1 ADEQ Disinfection Requirements

According to the A.A.C. Title 18 Chapter 9 (R-18-9-B204), no fecal coliforms (four of last seven daily samples) and less than 23 colony forming units per 100 mL (single sample maximum) are required to prove a facility is meeting the disinfection requirements of ADEQ BADCT for treatment facilities greater than 250,000 gpd. Unit treatment processes, such as chlorination-dechlorination, ultraviolet disinfection, and ozone, may be used to achieve this standard. Alternatively, ADEQ may approve soil aquifer treatment for the removal of fecal coliform as an alternative to meeting the disinfection requirement. This requires the permit applicant to document performance of the site in a design report or hydrogeologic report.

Table 1.6 ADEQ Reclaimed Water Quality Standards
Technical Memorandum No. 1 - Regulatory, Compatibility, and Reliability Requirements
City of Prescott, Arizona

Parameter	Effluent Limits Class A+ (1)	Class B+ (2)	Class C (3)
Secondary treatment	X	X	Stabilization ponds with 20-day detention
Filtration	X	NR	NR
Denitrification	X	X	NR
Disinfection	X	X	With or without
Total Nitrogen (as N) (4)	< 10 mg/L	< 10 mg/L	N/A
Turbidity			
Daily (24-hour) average	2 NTU	N/A	N/A
Single sample maximum	5 NTU	N/A	N/A
Fecal Coliform			
Single sample maximum	23 cfu/100 mL	800 cfu/100 mL	4,000 cfu/100 mL
Four out of last seven daily samples	None detect	200 cfu/100 mL	1,000 cfu/100 mL

Notes:
X = Requirement
NR = Not Requirement
(1) Reference: A.A.C. R-18-11-303
(2) Reference: A.A.C. R-18-11-305
(3) Reference: A.A.C. R-18-11-307
(4) Five sample geometric mean

3.6.2 ADEQ Disinfection By-Product Requirements

As part of the BADCT requirements, the A.A.C. requires all new sewage treatment facilities to minimize total trihalomethanes (TTHMs) generated as disinfection byproducts to the greatest extent practical, regardless of cost. The requirement can be met using chlorination, dechlorination, ultraviolet, or ozone as the disinfection system, or through implementation of a technology demonstrated to have equivalent or better performance for removing or preventing TTHMs.

There is no current numerical standard for TTHMs in Arizona for reuse, even though BADCT and Class A+ Reuse Rules both require minimization of TTHMs.

For recharge, the A.A.C. requires that any water discharged to a drinking water aquifer must meet the drinking water quality standards. Therefore, a TTHM level of 80 µg/L (Stage 2 Disinfection / Disinfection By-Product Rules) applies to the recharge water. Although surrogate studies indicated efficient removal of TTHMs to ambient concentrations after 6 months of travel time, reduction of TTHM via soil aquifer treatment has not been well assessed (An Investigation of Soil Aquifer Treatment for Sustainable Water Reuse, AWWARF, 2001). It is prudent to expect that recharging water with TTHM level exceeding 80 µg/L will be subjected to scrutiny and would likely not be approved by regulatory authorities.

3.6.3 Potential Future Requirements on Disinfection and TTHMs

Concerns about water quality and potential health hazards led to California issuing guidelines for groundwater recharge which recommended spreading over injection, disinfection prior to recharge, and minimization of DBPs. With the rising public concerns on health hazards associated with TTHM formation and non-disinfected recharge water, it is anticipated that ADEQ will enact requirements on recharge stream disinfection and TTHM compliance in the near future.

Reclaimed water may exceed the anticipated aquifer water quality standards for reclaimed water of 80 µg/L (Stage 2 Disinfection / Disinfection By-Product Rules). TTHM issues are typically related to the disinfection method and to presence of disinfection byproduct precursors (e.g., TOC, bromide, pH, temperature). Unless disinfection byproduct precursors are removed or reduced, the addition of chlorine will cause the formation of TTHMs, which when recharged, may exceed aquifer water quality standards. Therefore, we recommend evaluating the TTHM formation potential of the Sundog WWTP and Airport WRF effluent as part of a disinfection alternatives evaluation. TTHM formation potential tests can help in evaluating the viability of chlorination as a disinfection method that meets the anticipated aquifer water quality standards for reclaimed water of 80 µg/L.

3.6.3.1 NWRI UV Design Guidelines

Disinfection with ultraviolet technology has become a common practice in many states, because this technology does not rely on chemical for disinfection and therefore it does not generate disinfection byproducts as part of the disinfection process.

The National Water Research Institute (NWRI) UV Disinfection Guidelines were developed in an effort to standardize UV system design among manufacturers and consultants for water reuse applications. The California Department of Health Services (DHS) is applying the NWRI guidelines of UV disinfection design to meet Title 22 regulations. Many other states are currently looking at adopting NWRI guidelines to regulate UV disinfection processes.

The NWRI UV disinfection guidelines require that UV reactors be validated to prove their disinfection capabilities. This is done by evaluating UV dose delivered based on multiple factors. For water reuse applications, the standards require differing amounts of UV dose to be delivered to the process water depending on the type of filtration.

3.7 Emerging Contaminants and Reuse

Emerging contaminants are a class of compounds that include endocrine disruptors, pharmaceuticals, and personal care products. These compounds may pose long-term health effects even if ingested in small quantities (in the microgram and nanogram/liter range). With the advent of new analytical techniques capable of measuring extremely low concentrations, numerous trace organic compounds have been detected in treated wastewater. Some of the compounds (e.g. N nitrosodimethylamine [NDMA]) that have been identified in treated effluents are known to cause acute and chronic health effects depending on the concentration. However, the long-term health and environmental effects of most emerging contaminants are not yet well understood.

The United States Geological Survey (U.S.G.S.) completed a nationwide survey in 2000 that tested for the occurrence of pharmaceuticals, hormones, and other organic wastewater contaminants (OWCs) in streams across the U.S. A total of 139 streams in 30 states were tested for 95 OWCs using five new research methods developed by the U.S.G.S. All the sampling locations selected were located near urban areas. The four sampling locations were selected in Arizona including the Santa Cruz River near Rio Rico, the City of Phoenix 91st Avenue Wastewater Treatment Plant (WWTP) outfall, the Santa Cruz River at Cortaro Road, and the Gila River above diversions, at Gillespie Dam.

At least one OWC was detected in 80 percent of the streams sampled, with 82 of the 95 analyzed OWCs detected in at least one sample. Steroids, nonprescription drugs, and an insect repellent were the three chemical groups most commonly detected in the streams. Detergent metabolites, steroids, and plasticizers were generally found at the highest concentrations.

Endocrine disruptors, pharmaceuticals, and personal care product are contaminants that could be regulated in the future. Although it is too early in the regulatory process to determine which contaminants may be regulated and to what level, the City should be aware of these contaminants and understand the impacts of possible future regulations. The removal of such contaminants should also be taken into consideration when master planning and implementing the advanced treatment processes at the City's treatment facilities.

3.8 Emerging Organisms

Bryozoans are tiny colonial animals that typically build stony skeletons of calcium carbonate, superficially similar to coral (although some species lack any calcification in the colony and instead have a mucilaginous structure). Members of the Phylum bryozoa are known as “moss animals”, “moss animalcules” or “sea mats”. They generally prefer warm, tropical waters, but are known to occur worldwide. There are approximately 8,000 living species, with several times that number of fossil forms known.

Several species of freshwater bryozoans are notorious for clogging pipes that carry unfiltered water from rivers and lakes. The branching, tubular animal colonies attach firmly to any solid substrate, often appearing as clumps of brownish moss. In the last century, major cities in Europe and the United States have experienced disruption of public water service due to blockages by bryozoans (Kraepelin, 1886).

Bryozoan biofouling has been reported at multiple water and wastewater treatment facilities in the United States, including many local facilities. The City of Tempe Kyrene Water Reclamation Facility has been plagued with a microscopic bryozoa organism. Bryozoa typically grows in clear water with minimal sunlight. The existing covered final clarifiers, filters and effluent channels provided a perfect environment for bryozoa to form sheets of sticky growth on the walls. Periodically, the sheets would slough off the walls and quickly plug the effluent filters. There is no clear reason why the facility was infected, but the operators determined there was not an easy fix beyond methodically cleaning the filters and preparing for the next outbreak. The plugging filters resulted in fecal coliform issues and high O&M costs associated with the required cleaning.

At other local facilities, Bryozoa caused problems from fouling secondary clarifiers to plugging recharge wells. Moreover, Bryozoa occurrence can compromise disinfection and ruin UV lamps.

Bryozoa is resistant to chemicals such as chlorine. Process control measures including lowering the DO may help to reduce its growth. Based on the Kyrene WRF experience, membrane filtration may be less vulnerable to bryozoa plugging than conventional filtration.

3.9 Salinity and Reuse Potential

3.9.1 Total Dissolved Solids

TDS is the total quantity of salts dissolved in water and is comprised of anions, such as bicarbonate, carbonate, chloride, sulfate, and silica, and cations, such as sodium, calcium, and magnesium. TDS originates in natural geologic formations and is concentrated in processes such as irrigation return and field run-off, water reclamation, and membrane technologies.

Salt build-up in some areas of Arizona (such as the Phoenix metropolitan area) is a growing concern. Salt levels become more concentrated as water is used and reclaimed. Because the potential for reuse opportunities of reclaimed water diminishes (especially for irrigation uses) as salt concentrations rise, it is important to understand the importance of controlling salt build-up in the future. Due to the importance of establishing and maintaining reclaimed water as a viable future water supply, the City must be aware of the effects of increasing TDS. TDS removal and concentrate disposal alternatives may need to be examined in the future. As more efficient and practical methods of TDS removal and concentrate disposal evolve, the City should consider establishment of numerical TDS goals and implementation of control measures, as appropriate.

3.9.2 Whole Effluent Toxicity

Whole effluent toxicity (WET) describes the toxic effect to aquatic organisms from all pollutants found in a wastewater treatment facility’s effluent. WET tests measure wastewater's effects on specific test organisms' ability to survive, grow and reproduce. WET must be minimized to prohibit the discharge of toxic pollutants in toxic amounts. A chlorine level of less than 250 µg/L is recommended to lower the toxicity potential of the effluent.

The WET methods are specified in 40 CFR 136.3, Table IA. Any effluent parameter that meets the WET criteria will have requirements within the NPDES permit to control the toxic parameters.

3.9.3 Reclaimed Water Salinity and Sodium Adsorption Ratio

Sodium adsorption ratio (SAR) is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water. It is also a measure of the sodicity of soil, as determined from analysis of water extracted from the soil.

The formula for calculating sodium adsorption ratio is:

$$SAR = [Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$$

where sodium, calcium, and magnesium are in mequivalents/liter or mmole/liter.

Although SAR is only one factor in determining the suitability of water for irrigation, in general, the higher the sodium adsorption ratio, the less suitable the water is for irrigation. Irrigation using water with a high sodium adsorption ratio may require soil amendments to prevent long-term damage to the soil.

The City should be aware of the effects of reclaimed water recharge on TDS in the groundwater supply and resulting soil conditions. The City of Scottsdale has adopted a reuse water TDS goal of 1,000 mg/L and a sodium goal of 150 mg/L. As the result of a study at a City of Phoenix WRF, a chloride goal of 250 mg/L was proposed for toxicity reduction. While treatment may not be required to address salinity, sodium and chloride issues in the near term, these reuse water goals could be considered by the City when evaluating future available treatment technologies.

4.0 ODOR AND NOISE CONTROL

In recent years, the demand for odor and noise control at wastewater treatment facilities has increased significantly, as the general public is continuing to exert pressure on public officials to reduce odors and noise emitted from the treatment facilities. The purpose of this section is to review and summarize the odor and noise control requirements, and the implications for expanded wastewater treatment facilities.

4.1 General Site Aesthetic Regulatory Requirements

ADEQ has developed specific criteria relative to setback requirements for the design of water reclamation facilities. These setback requirements have been recently revised per the Arizona Administrative Code Title 18, Chapter 9, Subpart B201 (A.A.C. R-18-9-B201), as part of ADEQ's Aquifer Protection Permits (APP) process, with the associated requirements per the Best Available Demonstrated Control Technologies (BADCT) regulations.

As discussed in Section 3.4, an expansion of the treatment capacities of the Sundog WWTP and the Airport WRF will very likely require compliance with current BADCT requirements. For facilities with design flows over 1.0 mgd, such as the Sundog WWTP and Airport WRF, the minimum setback distances from the nearest property line are as follows:

- 1,000 feet if no odor, noise or aesthetic controls are provided; and
- 350 feet if full noise, odor, and aesthetic controls are provided.

The setbacks are defined by ADEQ in A.A.C. R-18-9-B201 as follows: "setbacks are measured from the treatment and disposal components within the sewage treatment facility to the nearest property line of an adjacent dwelling, workplace, or private property". According to ADEQ, full noise, odor, and aesthetic control means that:

- Noise due to the sewage treatment facility does not exceed 50 decibels at the facility property boundary on the A network of a sound level meter or a level established in a local noise ordinance;
- All odor-producing components of the sewage treatment facility are fully enclosed;
- Odor scrubbers or other odor-control devices are installed on all vents; and
- Fencing aesthetically matched to the area surrounding the facility.

As regards landscaping, per the ADEQ Engineering Bulletin No. 11, *Minimum Requirements for Design, Submission of Plans and Specifications of Sewage Works* (July 1978), "...aesthetic control is defined as landscaping in addition to chain link fences or earthen berms."

4.1.1 Setbacks for Existing Facilities

For wastewater treatment plants built before the existence of the required setbacks established in the BADCT requirements, there is a possibility that the minimum setbacks of 350 feet cannot be met. In those cases, ADEQ still requires that full noise, odor, and aesthetic controls be implemented, and that the expanded facilities do not further encroach into setback distances that existed before the modifications (A.A.C. R-18-9-B201).

Setbacks can also be decreased if allowed by local ordinances, or if waivers are obtained from affected property owners. Such waivers should include an acknowledgement by the affected property owner of the potential for noise and odor from the treatment facility.

4.1.2 Existing Setbacks

In order to define the available area for future capacity expansions, it is necessary to establish the existing setbacks at each of the City's wastewater treatment plants. Figure 1.1 presents the existing plant site of the Airport WRF with a delineation of the property boundary line, and a delineation of an internal 350-foot setback measured from the property boundary. According to the information obtained from the Yavapai County Assessor's database, the properties surrounding the plant site are not owned by the City of Prescott. Unless the City obtains signed waivers from owners of property adjacent to the plant site, the 350-foot and 1,000-foot setbacks need to be referenced from the plant property boundary.

The shortest setback distance between existing treatment units and the nearest property line at the Airport WRF is currently established by the distance between the existing sludge drying beds and the property boundary on the east side of the site, which is approximately 285 feet. None of the existing facilities at the site provides the setback of 1,000 feet required for no noise, odor, and aesthetic controls. Therefore, it is anticipated that full noise, odor, and aesthetic controls will be required with capacity expansion of the treatment facilities. Without signed waivers from adjacent property owners, all odor-producing facilities will need to be located within the 350-foot internal setback. The recharge basins are not considered odor-producing facilities and can be located outside of the 350-foot internal setback.

Figure 1.2 presents the existing plant site of the Sundog WWTP with a delineation of the property boundary line, and a delineation of internal 350-foot and 1,000-foot setbacks measured from City of Prescott's property boundary. According to the information obtained from the Yavapai County Assessor's database, most of the properties surrounding the plant site are owned by the City of Prescott. However, there is a property parcel located across Sundog Ranch Road, southeast from the previous sludge drying beds, which is owned by Yavapai County.

AIRPORT WRF SITE SETBACKS

FIGURE 1.1

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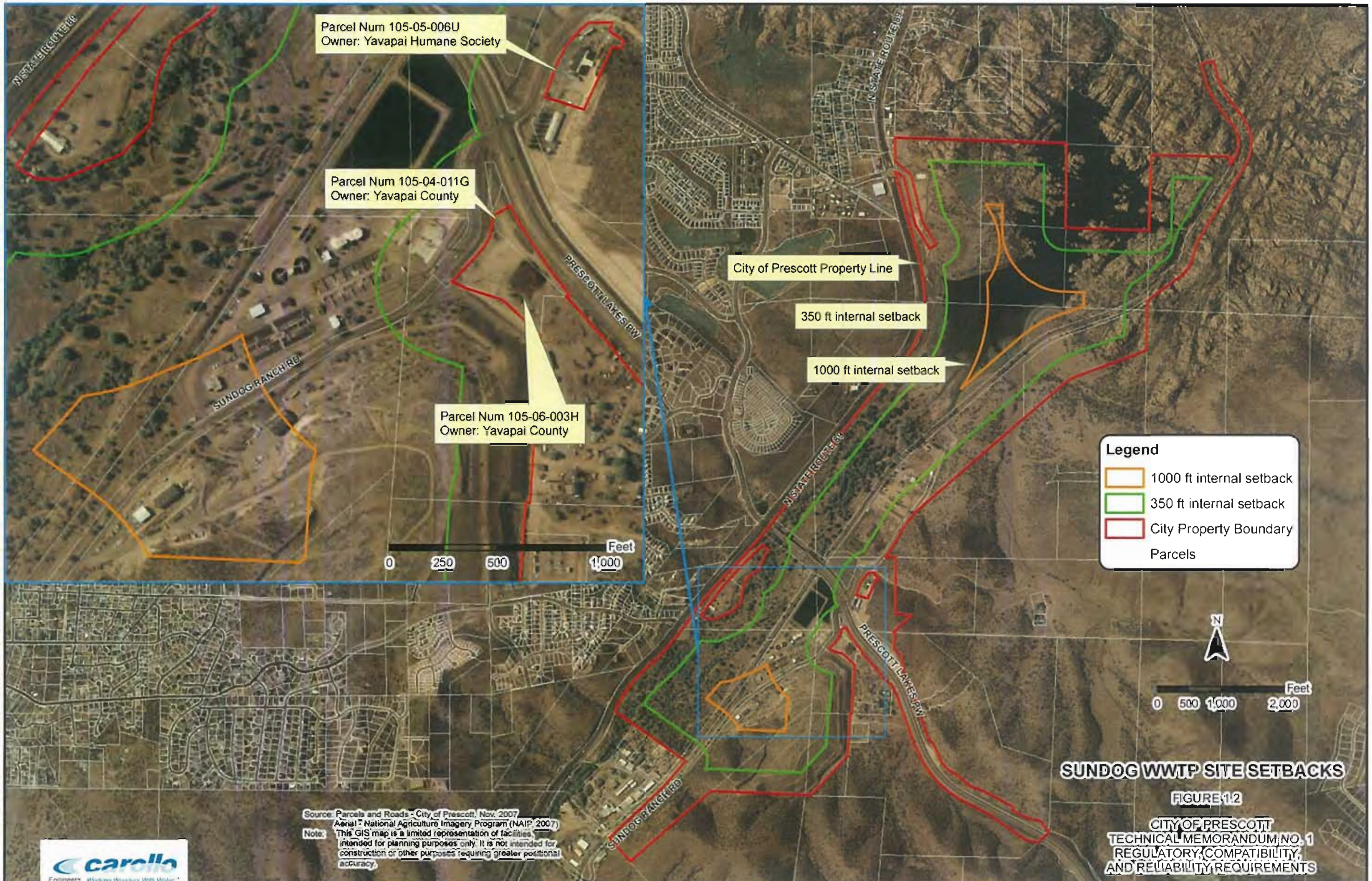
REGULATORY COMPATIBILITY, AND RELIABILITY REQUIREMENTS



SUNDOG WWTP SITE SETBACKS

FIGURE 1.2

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 1
REGULATORY, COMPATIBILITY, AND RELIABILITY REQUIREMENTS

The existing headworks and septage receiving facilities at the Sundog WWTP site are the only facilities that provide the setback of 1,000 feet required for no noise, odor, and aesthetic controls based on the City of Prescott property boundary lines. It is anticipated that full noise, odor, and aesthetic controls will be required with capacity expansion of the treatment facilities. All odor-producing facilities will need to be located within the 350-foot internal setback. The recharge basins are not considered odor-producing facilities and can be located outside of the 350-foot internal setback.

4.1.2.1 Section 404 Permits

In addition to the required setbacks for noise, odor, and aesthetic controls, Granite Creek may define additional setbacks at both sites. Granite Creek runs in the vicinity of both sites, and there will be a required area delineated by a defined distance from the centerline of Granite Creek dictated by the U.S. Army Corps of Engineers. The U.S. Army Corps of Engineers is the federal agency authorized to issue Section 404 Permits for activities conducted in U.S. waters. Coordination with the U.S. Army Corps of Engineers will be required when defining the required setbacks for the site master planning efforts. These setbacks will also affect the available area for construction of treatment facilities at both sites.

4.2 Odor Control Background

Odor-producing compounds found in domestic wastewater are typically small, relatively volatile molecules with molecular weights between 15 and 150. Generally speaking, the lower the molecular weight of a compound, the higher the volatility and potential for emission to the atmosphere. Substances of high molecular weight tend to be less volatile and soluble, but have lower odor thresholds.

Odors generated from domestic wastewater solids are also relatively low in concentration, but high in volume (i.e., highly diluted). Most of these compounds result from the anaerobic decomposition of organic matter containing sulfur and nitrogen. Inorganic gases produced from this anaerobic decomposition include hydrogen sulfide (H_2S), ammonia (NH_3), carbon dioxide (CO_2), and methane (CH_4). Other odor-producing substances include organic vapors such as mercaptans, indoles, skatoles, and nitrogen-bearing organics.

The primary offensive odors associated with domestic wastewater are H_2S, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide. These odors are often characterized by the following:

- Hydrogen sulfide - “rotten eggs”
- Methyl mercaptan - “decayed cabbage”
- Dimethyl sulfides - “decayed vegetables”

In liquid stream treatment, the odors can be significant at the headworks and primary sedimentation processes, but tend to lessen with each downstream unit process within the treatment facility. Solids processes tend to produce odors at least one order of magnitude greater than the liquid stream.

Although hydrogen sulfide (H_2S) is not the only odorant of concern in wastewater systems, it is usually one of the primary odorants and often the most significant, particularly at plant inlet facilities. H_2S is a colorless gas that is extremely toxic at high concentrations. It is also a precursor to the formation of sulfuric acid, which corrodes metals and concrete. Material selection for new construction will be particularly important to prevent damage within the enclosed areas. Typically, concrete in corrosive environments (e.g., headworks facilities) is protected by a high-build corrosion-resistant coating, and materials for equipment, pipe, supports, fasteners, and other appurtenances that must be located within enclosed spaces are either stainless steel or a suitable plastic.

H_2S typically causes some of the worst odor problems from the public's perception, because it can be sensed at very low concentrations by humans. The practical limit of detectability, or odor threshold level, is normally in the range of 1 to 10 parts per billion by volume (ppbv) in air. Therefore, it is imperative that all odor sources be contained and treated to very low outlet concentrations. Conditions leading to H_2S formation generally favor the production of other odorous organic compounds. Thus, solving H_2S problems can often alleviate odors from other compounds as well.

4.3 Site Odor Control Requirements

There are three primary areas where odor control will likely be required at both the Sundog WWTP and the Airport WRF:

- Preliminary treatment, including septage receiving station, influent pumping, screening, grit removal, and flow splitter structures;
- Primary treatment, including primary sedimentation basins and flow splitter structures;
- Solids handling and treatment, including blending, thickening, dewatering, loading, storage, and grease receiving station.

An intergovernmental agreement between Yavapai County and the City of Prescott (June 2007) establishes the intent to install covers on aeration tanks and construct a septage facility building at the Sundog WWTP for the purpose of odor control. This is currently under review by the City in light of recent operational changes and this master planning project.

Typically, secondary treatment process areas (activated sludge basins and secondary clarifiers) are not a major source of offensive odors. Aerobic processes (such as activated sludge aeration basins) commonly emit a characteristic “musty” odor, volatilized during the physical aeration process. Anoxic zones for denitrification of the wastewater tend to generate more foul air than aerobic zones. Odor control for the secondary processes is sometimes required by ADEQ per BADCT requirements. Therefore, discussions with ADEQ during preliminary design are recommended to determine odor control requirements for secondary process areas.

4.3.1 Preliminary Treatment

At the plant headworks, influent flow is pumped, screened and undergoes grit removal processes. The high turbulence produced by pumping, screening, and grit removal generally causes odor releases from the liquid streams, particularly H_2S.

There is a septage receiving station at the Sundog WWTP. Due to the anaerobic conditions of the received septage, high levels of H_2S are usually encountered and can be a significant source of odors. A new septage receiving station is anticipated at the Sundog WWTP. Odor control for the septage receiving station may be combined with other headworks facilities, such as screening and grit removal.

4.3.2 Primary Treatment Areas

Primary sedimentation basins usually present high levels of H_2S due to anaerobic conditions created in the collection system. Primary treatment is usually one of the major sources of odor in a wastewater treatment facility, and odor control is typically required to meet ADEQ BADCT requirements. Odor control for primary treatment basins may be combined with other facilities such as screening, grit removal, and septage receiving facilities.

4.3.3 Solids Handling and Treatment Process Areas

At the solids handling facilities, primary sludge and waste activated sludge undergo thickening, digestion, and dewatering. The sludge handling processes typically produce strong odors of reduced sulfur organics and H_2S concentrations likely up to 100 ppm (typically one order of magnitude higher than that in the headworks).

4.4 Noise Attenuation Background

Another important aspect of the “good neighbor” policy involves the assurance that noises produced by the treatment facilities will not disturb the surrounding community. Methods to reduce or even eliminate potential sources of noise are readily available and should be implemented at future expansions of the plants. The various unit processes should involve some form of noise attenuation to achieve the goal of reducing sounds generated on the plant site.

Efforts to provide noise attenuation are typically evaluated on two levels: the health and safety of operation personnel, and the comfort and acceptance of the surrounding community. In accordance with the A.A.C. BADCT requirements, the design for the treatment facilities should incorporate measures for full noise control.

There are three primary elements in any noise attenuation situation:

- Source - which generates the noise;
- Path - which transmits the noise from the source to the receiver; and
- Receiver - who hears the noise.

Noise reduction for any facility is based on evaluating these three elements. The impact of background noise, including existing environmental, transportation, and community noise sources in the absence of any audible construction activities, must also be considered. For the Airport and Sundog treatment facilities, reduction of the noise levels at the receiver is not practical, except for operations personnel, i.e., hearing protection. Therefore, any noise reduction that will be required should first be accomplished by reduction at the source to practical limits, followed by additional modifications to the transmission path.

Noise reduction at the source is dependent on the type of unit process or equipment in question. For typical equipment at wastewater treatment facilities, several options are available. The most effective solution is to enclose the equipment in buildings or other enclosures. This will be the case for many of the pumps, blowers, centrifuges, variable frequency drives (VFDs), and other mechanical equipment. Sound attenuation panels can be provided on walls and/or ceilings of buildings or structures, where appropriate. For extremely high noise generating equipment or equipment located outside buildings or enclosures, manufactured noise suppression appurtenances can also be provided.

- **Pumps.** Pumps can be provided with motor shrouds and/or increased level of motor insulation. For exposed pumps (i.e., effluent vertical turbine pumps), some type of sound attenuation wall may be required.
- **Mixers and Drives.** Mixers and drives (i.e., clarifier drives, etc.) can also be provided with motor shrouds and/or increased level of motor insulation. Some drives may be located within the dome covers.
- **Blowers.** Blowers will likely generate the highest level of noise. Centrifugal blowers are generally quieter than positive displacement blowers. Even within a building provided with sound attenuation panels, the blowers can be equipped with inlet and outlet silencers. The use of silencers can reduce single-stage centrifugal blowers to around 95 dBA at the source. Sound attenuation walls will likely be provided around the various odor control system fans.

In addition to source reduction methods, a sound barrier (i.e., wall, earthen berm, etc.) can be placed in the transmission path between the source and receiver to provide what noise control experts term a “shadow zone,” or reduced noise region on the receiver side. The shadow zone is limited by the ability of sound to “bend” around surfaces. The performance is also limited by reflections and direct transmission through the barrier.

4.5 Site Noise Attenuation Requirements

The A.A.C. BADCT for Sewage Treatment Facilities (A.A.C. R-18-9-B201) requires that noise due to the sewage treatment facility does not exceed 50 dBA at the facility property boundary. The term “dBA” is defined as the sound level (in decibels referenced to 20 micro-pascals) as measured using the A-weighting network on a sound level meter, in accordance with the American National Standards Institute (ANSI) S1.4 Standards.

5.0 RELIABILITY REQUIREMENTS

The main goal of having reliability and redundancy in the treatment process is to provide the ability to comply with the required effluent quality goals even at times when process units are temporarily taken out of service for maintenance or repair. This includes process equipment as well as electrical supply. The purpose of this section is to summarize process redundancy requirements as outlined in applicable design guidelines and regulatory requirements.

The main references used for process redundancy requirement recommendations are the ADEQ Engineering Bulletin No. 11 and the Recommended Standards for Wastewater Facilities, Wastewater Committee of the Great Lakes.

5.1 Redundancy Requirements

5.1.1 General

Bypassing raw sewage around the treatment process is prohibited. However, multiple process units should be provided to allow the ability to take a unit process out of service for maintenance or repair.

5.1.2 Emergency Power Requirements

All wastewater treatment facilities should have the ability to operate critical equipment during power failures. Alternate power can be provided via standby power generators, separate independent feeders from separate substations, or a loop feeder on separate transformers from a common substation.

Under some circumstances, standby power is not required for aeration equipment used in the secondary treatment process. When power outages with durations of more than four hours are frequent, standby power will be required for aeration equipment, such that minimum aeration is provided during the power outages.

Standby power to run disinfection equipment is generally required, when stringent disinfection requirements are in place. BADCT and Class A+ disinfection requirements require non-detect fecal coliform in four out of seven samples. If power outages are frequent, standby power for the full capacity of the UV disinfection system should be provided.

Influent and effluent pumping should be operated on standby power if failure to operate those pumping units would result in flooding or hazardous conditions.

While not critical, other processes that are desirable to run during power outages are influent screens and tertiary filters. The horsepower associated with those facilities is generally relatively small, but can help in avoiding wastewater overflows (headworks), and maintain a good quality tertiary effluent prior to the disinfection units.

5.1.3 Preliminary Treatment

Influent pumping capacity should be achieved with multiple units, including a fully redundant unit that is not necessary for pumping peak flows.

Screening facilities should include multiple units, with the ability to take one unit out of service and maintain the peak flow treatment capacity. Grit facilities should be provided with multiple units, or with a bypass to allow maintenance on a single grit removal unit.

5.1.4 Primary and Secondary Treatment

Multiple units or the ability to bypass flows to secondary treatment should be provided for primary treatment facilities. Multiple biological treatment basins should be provided. Similarly, multiple units should be provided for secondary sedimentation, and allow the capability of taking one basin out of service under annual average loading conditions.

Aeration equipment should include a standby unit that is not required to meet the maximum air demand. Return sludge and waste activated sludge pumping should include a fully redundant pumping unit.

5.1.5 Filtration and Disinfection

Multiple filtration units should be provided, to allow the capability of taking units out of service. Disinfection equipment should include sufficient redundancy to maintain the required effluent quality with a unit out of service.

6.0 SUMMARY

The main objective of this TM No. 1 was to analyze existing regulatory information that will affect the planning and design of future treatment facilities at the Sundog WWTP and Airport WRF. The analysis included requirements for effluent quality, odor control, and process redundancy, as well as potential future regulatory requirements on emerging issues. The main findings are summarized below:

- The Sundog WWTP and Airport WRF currently have permitted capacities of 6.0 mgd, and 2.2 mgd monthly average flow, respectively. The recharge basins at the Airport WRF site are permitted to receive effluent from both treatment facilities with a permitted capacity of 4.4 mgd as a monthly average flow.
- The Sundog WWTP and the Airport WRF are currently permitted to produce Class B+ quality effluent, according to their current Aquifer Protection Permits. Class B+ quality is adequate for golf course irrigation, as well as for other restricted-access uses such as landscape irrigation and construction-related activities.
- The City is currently reusing and/or recharging (depending on seasonal irrigation usage) all of its reclaimed water. If the City ever considers surface water discharge as an effluent disposal method, an AZPDES permit would be required, and the numerical standards associated with the surface water discharge regulations would need to be met.
- Any significant major expansion at the Sundog WWTP and the Airport WRF will require compliance with ADEQ BADCT requirements. The technology assessment performed under this project shall only consider technologies that are capable of achieving the minimum effluent water quality parameters specified per BADCT standards. Disinfection requirements per BADCT are equivalent to those for Class A+ reclaimed water.
- There is no current numerical standard for TTHMs in Arizona for reuse, even though BADCT and Class A+ Reuse Rules both require minimization of TTHMs. For recharge, the A.A.C. requires that any water discharged to a drinking water aquifer must meet the drinking water quality standards. Therefore, a TTHM level of 80 µg/L (Stage 2 Disinfection / Disinfection By-Product Rules) applies to the recharge water.
- Endocrine disruptors, pharmaceuticals, and personal care product are contaminants that could be regulated in the future. It is too early in the regulatory process to determine which contaminants may be regulated and to what level. However, the City should be aware of these contaminants and understand the impacts of possible future regulations.

- Salt build-up in some areas of Arizona (such as the Phoenix metropolitan area) is a growing concern. Salt levels become more concentrated as water is used and reclaimed. Because the potential for reuse opportunities of reclaimed water diminishes (especially for irrigation uses) as salt concentrations rise, it is important to recognize the importance of controlling salt build-up in the future.
- BADCT requirements establish that minimum setbacks must be maintained for water reclamation facilities. A setback of 1,000 feet should be maintained if no odor, noise or aesthetic controls are provided. A setback of 350 feet if full noise, odor, and aesthetic controls are provided. These setbacks can be decreased if allowed by local ordinances, or if waivers are obtained from affected property owners.
- Odor control measures will likely be required at both facilities per BADCT requirements. The majority of the odors originate from headworks, primary sedimentation, and solids handling processes, and special emphasis should be placed in providing odor control for those facilities.
- Reliability and redundancy in the treatment process should be included in future designs, in order to provide the ability to comply with the required effluent quality goals even at times when process units are temporarily taken out of service for maintenance or repair.

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 2
Control System Standards

Final

In Association with

Project No. 164890

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City of Prescott

**TECHNICAL MEMORANDUM
NO. 2
CONTROL SYSTEM STANDARDS**

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ES2 TM 2 – CONTROL SYSTEM STANDARDS

ES2.1 Introduction

As part of the Sundog WWTP and Airport WRFs Capacity and Technology Master Plan, Black & Veatch was tasked with evaluating the City of Prescott Water SCADA system as designed for the Big Chino Pipeline Project and provide similar recommendations for implementation on the waste water system. However, the Big Chino Pipeline Project has not been constructed and the City of Prescott acknowledged that additional research into a standard control system was warranted.

Therefore, the original task was amended and B&V was asked to document a standard approach for design of control systems within the water treatment, wastewater treatment, distribution and collection systems such that equipment installed could be easily implemented into a future common SCADA system. A technical memorandum (TM-2 Control System Standards) would be prepared to document the resulting control system standards.

ES2.2 Recommended Control System Standards

Black & Veatch conducted a workshop at the City of Prescott to gather information regarding the specific requirements for future control systems and to determine the preferred control philosophies to be incorporated into the technical memorandum. Following is a summary of the control system discussions at the workshop and resulting standards included in TM-2.

- TM-2 should be a living document and should be updated as newer products become available and as additional City of Prescott standards are developed.
- A SCADA system software package has not been selected at this time.
- The City of Prescott staff had completed evaluations of various PLC manufacturers. Rockwell Automation Allen-Bradley (AB) is the preferred PLC manufacturer. TM-2 identifies the AB Logix control platform and RSLogix 5000 as the required programming software.
- Operator Interface Terminals (OIT), when necessary, should be AB Panelview Plus or Direct Automation and shall have Ethernet/IP communication.
- Control systems should be designed capable of Ethernet/IP communications to future SCADA system. Rockwell Automation Stratix Switch should be included in all PLC cabinets. An example network diagram is included in TM-2.
- Standard equipment control modes were established for Local, Auto, Remote, and SCADA as well as standard lights, alarms and status signals.

- Typical control philosophies and standard P&IDs for constant speed pumps, variable speed pumps, digital valve actuators and analog valve actuators are defined. These include typical monitoring, control and interlocks.
- Typical interface requirements for flowmeters, pressure transmitters and analog instruments in addition to typical P&IDs are included.

1.0 INTRODUCTION

The City of Prescott (COP) owns and operates numerous water treatment, wastewater treatment, distribution, and collection facilities. These facilities have been constructed over the years following different specification and design documents from various consultants, leaving the COP with a wide variety of control system philosophies. The implementation of these different philosophies create a burden on the COP operations and maintenance staff since each location has variations in interlocks, control stations, programmable logic controllers, etc. which result in increased manpower for troubleshooting and maintenance activities.

In addition, the COP is planning to implement a department-wide Supervisory Control and Data Acquisition (SCADA) system which will be capable of monitoring and control of the water and wastewater systems from one or more central locations. While implementation of the SCADA system is not yet started, the COP desires to establish control system standards for all new and upgrade projects such that interface with the future SCADA system can be done as easily as possible.

The intent of this document is to define the control system standards for all new and upgrade projects. It is intended that these standards will be a living document and will be enhanced or updated over time; therefore a revision number at the bottom of each page will be provided. Major revisions will be documented with an increment to the number before the period. Minor revisions will require an increment to the number behind the period.

2.0 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

The City of Prescott has evaluated the various PLCs they currently have in service in conjunction with the current platforms provided by the PLCs manufacturers and have selected Rockwell Automation Allen-Bradley (AB) Logix control platform as their standard programmable logic controller family. All new PLCs provided for new facilities and upgrades to existing facilities should utilize the AB Logix controllers and should be programmed using RSLogix 5000 programming software. The Designer should inquire with the City on every project if a copy of the licensed RSLogix 5000 programming software is required to be turned over at the end of the project.

Each PLC processor should be sized to support the required I/O, communication, process functions, data storage, and spare I/O required for the project. Communication ports should be provided to support the necessary networking requirements of the specific project plus one spare Ethernet/IP port for uploading and downloading PLC application programs and one spare Ethernet/IP port for connection to a future system wide SCADA system. Additional networking requirements are covered elsewhere in this document.

Large PLC processors should be used for complex control or for large plant SCADA systems. The PLC shall include battery backed memory to retain the program during a power failure. For increased protection against program loss, PLCs may be provided with optional EPROM memory and should be configured to automatically download the program when power to the system is restored. Large PLC processors should be AB ControlLogix.

Small PLC processors may be used for small stand alone packages, lift stations, or small pumping stations. The PLC should include battery backed memory to retain their program during a power failure. Small PLC processors should be AB CompactLogix.

Remote I/O racks may be used in applications where several I/O points need to be bought back to the control system and a local processor is not required or cannot be justified. Remote I/O racks should be AB FlexIO.

Input/Output hardware should be specified as follows.

- Digital input and output modules should be 24 volt dc.
- Analog input and output modules should be 4-20 mA dc.
- High speed pulse accumulator modules should be used for flowmeter pulse inputs.
- Platinum RTD analog inputs should be used

3.0 OPERATOR INTERFACE TERMINALS (OIT)

Operator interface terminals should be provided in applications when operations or maintenance staff require access to functions, setpoints, equipment status and alarms within the PLC. OITs should be microprocessor based flat panel type and should be capable of Ethernet/IP communications to one or more PLCs as required for the application. The Designer should inquire with the City if a copy of the OIT software license should be provided to the City upon completion of commissioning of the system. Operator interface terminals should be Allen-Bradley PanelView Plus or Direct Automation.

4.0 CONTROL SYSTEM NETWORKING

It is not the intent of this document to define the entire control system network however each design should allow for flexibility in the future. The future SCADA system will utilize Ethernet/IP communication from PLC to SCADA work stations and from PLC to PLC. As previously defined, the PLCs and OITs should be capable of Ethernet/IP communication and adequate Ethernet/IP ports are required for all equipment necessary for the specific project plus one spare for interface with the future SCADA system and one spare for downloading PLC application program.

In order to accomplish this, it is recommended that a Rockwell Automation Stratix Switch with RSLogix5000 Add On Profile be provided in each PLC cabinet. If not required for the current project, space should be provided to allow for the addition of a switch in the future. In addition, for remote locations that may require radio communications, either now or later, space should be provided in the PLC cabinet for an Ethernet radio. An example network diagram is shown in Figure 4.1.

On a project specific basis, device networks for connection to variable frequency drives, motor control centers, instruments, valves, etc., may be considered. In the event that device networks are utilized, DeviceNet should be used due to ease of development with the Allen-Bradley control system.

Networking of power monitoring equipment for the power distribution equipment and large motors should be evaluated on a project basis and if deemed advantageous, Ethernet/IP should be utilized.

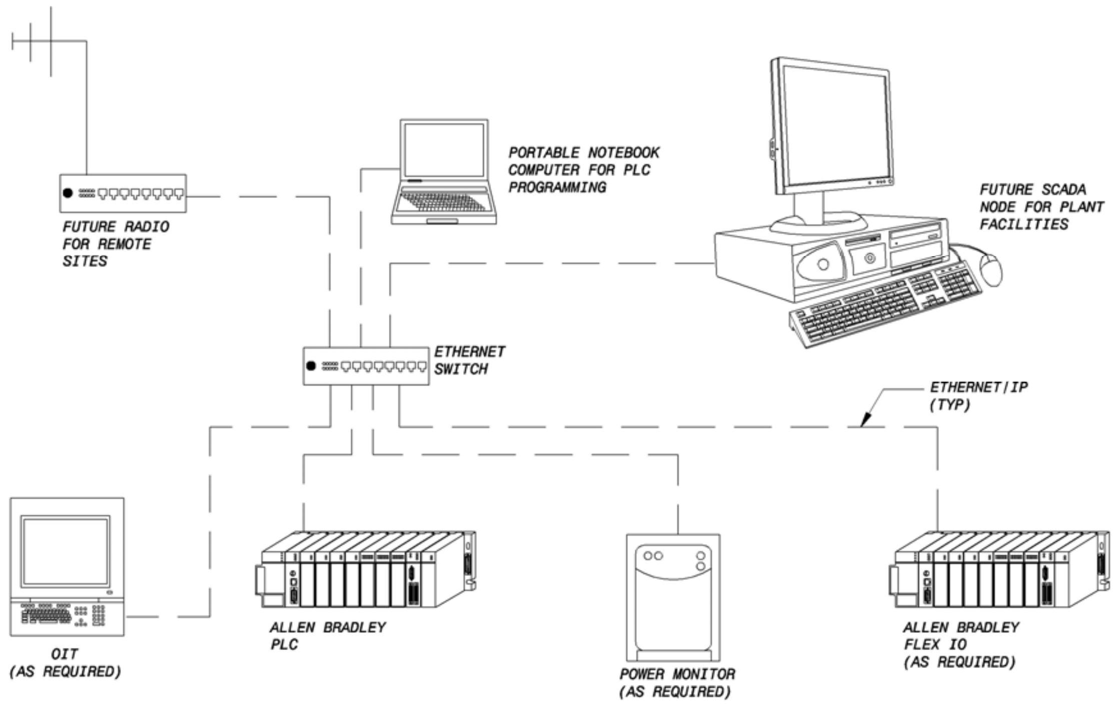

Figure 4.1 Example Control System Network Diagram for Typical Installation

5.0 EQUIPMENT CONTROL MODES

Standard equipment control modes have been established and should be followed unless otherwise directed or approved. Typical control modes are as follows:

Most individual pieces of equipment should be provided with a HAND-OFF-REMOTE selector switch and START-STOP push buttons. When the selector switch is in HAND, the equipment will be controlled using the START-STOP push buttons. When the selector switch is in REMOTE, the equipment will be controlled through a plant control system PLC. Equipment being controlled by the PLC may be controlled from an OIT or future SCADA software. OIT or future SCADA software controls are not covered in detail however the OIT should include both manual and automatic control as appropriate for the system being controlled.

Occasionally, it may be desirable to include an ON position with the selector switch and when selected, the equipment will run without the use of push buttons. ON control would be typically used for equipment which needs to run all of the time.

Equipment which operates using local controls that are not dependant on the plant control system but require automatic operation should include a HAND-OFF-AUTO selector switch. AUTO control should be used for stand alone equipment not controlled by the plant control system. Examples would include sump pumps, compressors, and generators.

LOCK-OUT-STOP push button may be provided near equipment for safety reasons and shall prevent equipment from running in any mode. LOCK-OUT-STOP push buttons should be located at the equipment.

Indicating light standards shall be as follows:

- RED – Off
- GREEN – On
- AMBER – alarm
- WHITE – power on

Location of physical selector switches and push buttons shall be determined on a project basis. Typically, local controls will reside on the starter, motor control center, or local control panel.

Some equipment may require local alarms and interlocks. Critical alarms/interlocks should be hard wired to shut equipment down in any mode and will require an alarm to the PLC. Non-critical alarms shall be sent to the PLC but may not require a hardwired interlock to shut the equipment down. Critical alarms shall require a local reset. Non-critical alarms may be reset manually from the OIT or automatically within the PLC, as appropriate.

6.0 EQUIPMENT CONTROLS AND MONITORING

Typical control and monitoring of equipment from a PLC has been established and should be followed unless otherwise directed or approved. Typical PLC control and monitoring requirements are as follows:

The control of equipment in REMOTE should typically require a single maintained discrete output from the PLC as a run command. The PLC should receive discrete input feedback from the equipment for run status, fail/overload status, and selector switch status (i.e. In Remote). If the equipment has any specific interlocks such as high discharge pressure or low water cutoff, these interlocks should also be monitored by the PLC. If local disconnects are provided at the equipment, disconnect position feedback should be provided.

Equipment controlled by a variable frequency drive should also include an analog output from the PLC for speed control and an analog input to the PLC for speed feedback. Example P&IDs for a constant speed pump and variable speed pump are shown in Figure 6.1 and Figure 6.2.

Electric valve actuators require an Open command and Close command discrete output from the PLC for digital open-close actuators and a 4-20 mA position control analog output from the PLC for analog modulating actuators. The PLC should receive discrete input feedback from electric valve actuators for selector switch in remote status, full open status, and full closed status. In addition, the PLC should receive a 4-20 mA position feedback analog input from variable position actuators. Example P&IDs for digital and analog actuators are shown in Figure 6.3.

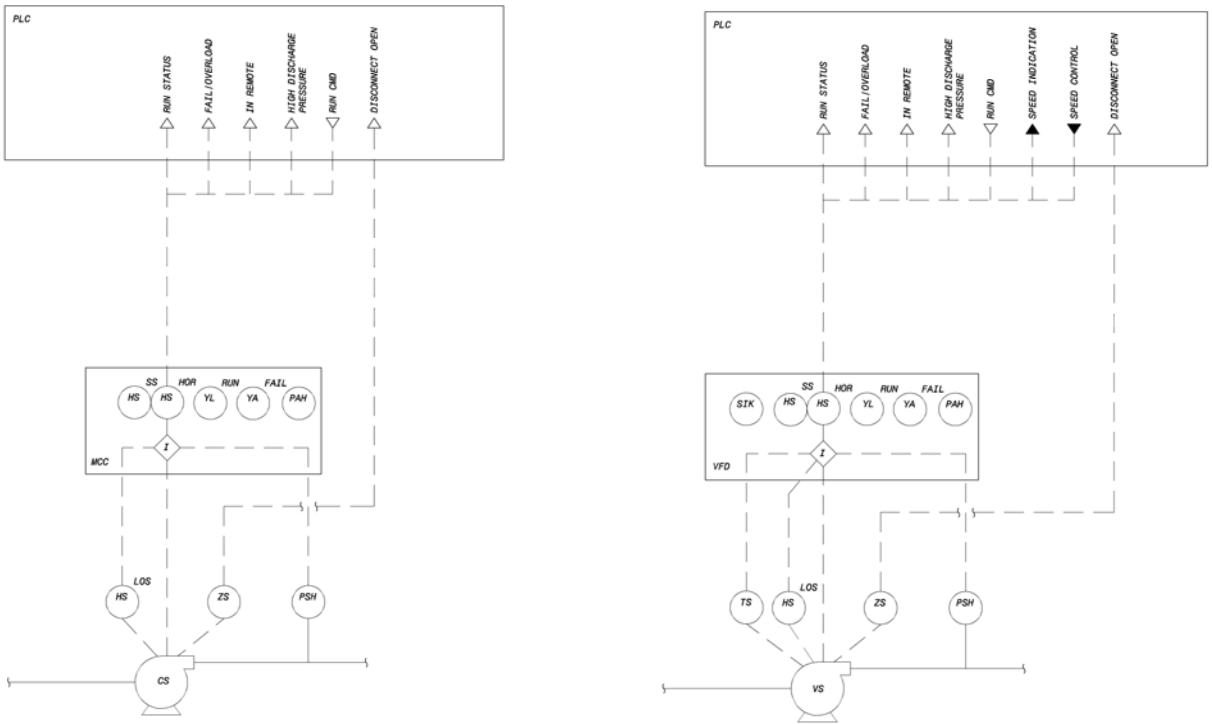

Figure 6.1 Typical P&ID Representation for Constant Speed and Variable Speed Pumps

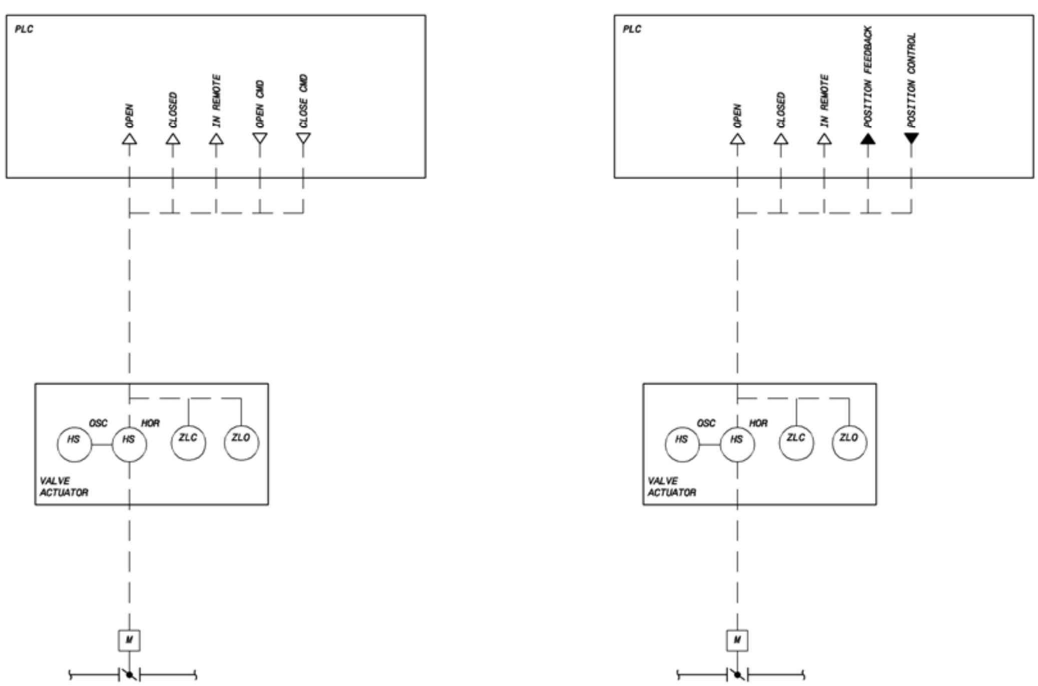

Figure 6.2 Typical P&ID Representation for Digital and Analog Valve Actuators

Packaged OEM equipment provided with a PLC should be networked to the control system PLC with Ethernet/IP. If a PLC is not required for the OEM equipment, equipment running and common alarm discrete inputs should be provided to the PLC. If required, an enable PLC discrete output should be provided to packaged OEM equipment.

Analog instruments should be provided with isolated 4-20 mA analog inputs to the PLC. Flowmeters should provide, in addition to the analog input, a pulse input for totalization to a high speed pulse accumulator module in the PLC. Example P&IDs for a magnetic flowmeter, pressure transmitter, and analog instrument are shown in Figure 6.3.

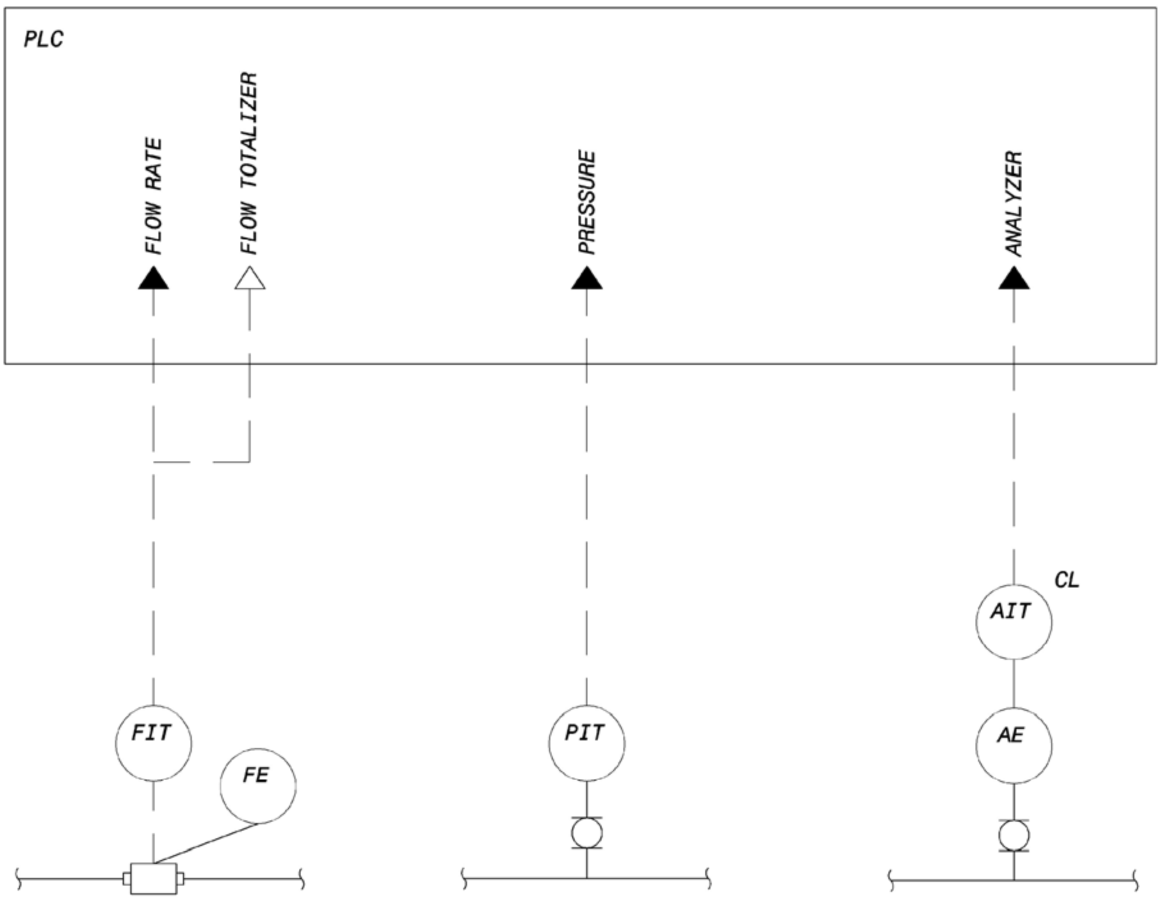

Figure 6.3   Typical P&ID Representation for Magnetic Flowmeter, Pressure Transmitter and Analytical Instrument

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 3S
Sundog WWTP Existing Conditions

Final

In Association with

Project No. 164890

City of Prescott

TECHNICAL MEMORANDUM
NO. 3S
SUNDOG WWTP EXISTING CONDITIONS

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ES3S TM 3S – SUNDOG WWTP EXISTING CONDITIONS

ES3S.1 Introduction

The purpose of TM 3S is to gather, organize and document existing conditions for the Sundog WWTP, including available data, physical conditions of existing facilities, existing treatment capacity, and operational issues.

The Sundog WWTP is the City's largest wastewater treatment plant and currently receives the majority of the City's wastewater flow. The existing Sundog WWTP was last expanded in 1990, and designed for a treatment capacity of 6.0 mgd AADF. The liquid treatment process was upgraded to include primary clarification denitrification and filtration. The purpose of the process upgrade was to provide an effluent of suitable quality for irrigation of open-access turf sites and aquifer recharge by means of percolation recharge basins constructed near the Airport WRF under the same contract.

ES3S.2 Existing Information

Table ES3S.1 presents the hydraulic design criteria used for the most recent 1990 Sundog WWTP expansion.

Table ES3S.1 Existing Hydraulic Design Flows
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	1990 Design
Annual average daily flow, mgd	6.0
Maximum month average daily (design) flow, mgd	6.5
Maximum day flow, mgd	12.0
Hydraulic capacity, peak (hour), mgd	15.0

Table ES3S.2 presents the wastewater characteristics used for the most recent 1990 Sundog WWTP expansion.

Table ES3S.2 Design Wastewater Characteristics and Concentrations
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Characteristics	Average mg/L	Maximum Month mg/L
BOD_5	152	166
TSS	165	171
TKN	24	30
Temperature, °C		
Summer	25	
Winter	10	

The existing Sundog WWTP includes the following facilities:

- Headworks
  - Bar screens
  - Grit removal (vortex type)
- Primary Clarifiers
  - Conversion of existing final clarifiers
- Oxidation Ditches
  - Anoxic zones
  - Supplemental diffused aeration
  - Blower buildings
- New Circular Final Clarifiers
- Return Activated Sludge (RAS) Gravity fed to Screw Pumps
- Waste Activated Sludge (WAS) / Scum Pump Station
- Traveling Bridge Filter
- Chlorine Contact Basins
- WAS Thickening Anaerobic Digestion
- Belt Filter Press

The Sundog WWTP currently operates under Aquifer Protection Permit (APP) No. P-100353 which permits the plant for Class B+ effluent. Moving forward master planning will be based on technologies capable of producing Class A+ reclaimed water suitable for unrestricted reuse.

ES3S.3 Physical Conditions

The original coordinate system for the Sundog WWTP used the Arizona State Plane coordinate system.

The project benchmark was based on a brass cap set on USGS benchmark M-27 located on Oxidation Ditch 1 walkway. The project benchmark elevation was determined to be 5197.48 based on the City of Prescott Datum.

A geotechnical site investigation was performed in 1988 by Gellhaus Engineering and Testing Laboratories. Groundwater was not encountered in any of the test holes to the depths drilled.

The existing soil conditions are a mixture of sandy clay (SC) and gravelly clay (GC). Soft fill soils were encountered throughout the site. Overexcavation of the soft soils was required for the structure foundations.

A site walk was conducted on June 8, 2009 with the operation staff to assess the current condition of the existing Sundog WWTP equipment and structures. Inspections were limited to structure and equipment above or out of water. Major findings include:

- The headworks structure is in good condition. The influent screen and grit basin equipment exhibit some minor corrosion and wear on moving parts.
- The primary clarifier weirs show signs of corrosion and should be replaced. The primary sludge pumps are nearing the end of their life cycle and exhibit heavy corrosion.
- The area along the northeast corner of the oxidation ditches show signs of settlement as shown in Figure 3.1. The mounts for the brush rotors and gear box show significant concrete failure.
- The secondary clarifier basins appear to be in good structural condition. One of the clarifier drive mechanisms experienced issues with the gear box requiring replacement. The second clarifier drive mechanism is beginning to exhibit similar symptoms and may need replacement in the near future.
- The existing underdrains for the traveling bridge filters have failed and are in need of replacement. A full assessment of the current condition of the traveling bridge filters is located in TM 7 Tertiary Filtration Evaluation.
- The existing chlorine contact concrete basin is in good condition. The UV disinfection equipment is in good condition with little sign of wear. No significant issues were located during the tour.

- Two gravity belt thickeners were originally installed in the Solids Processing Building. One of the units has been stripped of parts to maintain the other unit in operation.

- A single belt filter press is located in a prefabricated metal building adjacent to the Solids Processing Building. The building lacked appropriate ventilation and corrosion protection resulting in severe damage to the building structure. The belt filter press itself shows signs of corrosion and heavy equipment wear. The existing belt is misaligned creating operational issue. The belt and rollers have heavy struvite accumulations. Additionally, the unit shows significant signs of rotting and is at the end of its useful life. The unit will not continue to operate in the long term.

ES3S.4 Capacity Analysis

The Sundog WWTP was modeled to evaluate performance of the existing facilities under current loadings to determine current treatment capacity.

Current average annual flow and peak flow factors are presented in Table ES3S.3 based on historical plant data between January 2006 and April 2009.

Table ES3S.3 Current Hydraulic Evaluation Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Current Average Annual Flow (mgd)	2.58
Historical Hydraulic Peaking Factor	
Maximum Month : Average Day	2
Peak Day : Average Day	3.3
Peak Hour : Average Day	4.5

Influent wastewater characteristics were also determined from an analysis of plant historical records between 2006 and 2009. Influent wastewater characteristics used to establish existing Sundog WWTP treatment capacity are presented in Table ES3S.4.

Table ES3S.4 Current Wastewater Influent Loadings
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Parameters	Average (mg/L)	92%ile Max Month (mg/L)	92% Max Month: Average Annual Peak Factor	Summer Max Month Load (ppd)	Winter Max Month Load (ppd)
BOD_5	390	608	1.56	2.58x608x8.34= 13,082	2.58x2x390x8.34= 16,783
TSS	418	676	1.62	2.58x676x8.34= 14,545	2.58x2x418x8.34= 17,988
TKN	39.5	57	1.39	2.58x57x8.34= 1,226	2.58x2x39.5x8.34= 1,700
NH3-N	31.5	48.8	1.52	2.58x48.8x8.34= 1,050	2.58x2x31.5x8.34= 1,356

Note: The winter peak load used for evaluation purposes is 30/38% higher than the maximum month load measured in 2006/2009. The reason for this anomaly is to account for the extremely high winter loads measured in 2006/2007.

A comparison of current existing wastewater flow and loading with the 1990 basis of design values is presented in Table ES3S.5. As shown the average influent flows are 43% of the 1990 design values. However, the average BOD and TSS mass loadings are approximately the same indicating a dramatic increase in wastewater strength.

A process model (BioWin™) was used to evaluate the treatment capacity of the Sundog WWTP.

The BioWin™ model was configured to simulate the existing unit processes at the Sundog WWTP as summarized in Table ES3S.6. The BioWin™ model schematic is shown in Figure ES3S.1.

Table ES3S.5 Current Influent Wastewater Concentrations Compared with 1990 Design Values
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Existing Conditions		Current Conditions (1990)	
	Average	Max Month	Average	Max Month
BOD_5 (mg/L)	373	608	152	166
TSS (mg/L)	402	676	165	171
TKN (mg/L)	39.5	57	N/A	N/A
NH_3-N (mg/L)	31.5	48.8	24	30

Table ES3S.6 Wastewater Treatment Process Units for Modeling Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona		
	Existing Process Equipment	
	Number	**Parameters**
Primary Clarifiers	2	Area = 4,350 ft^2 each SWD = 10ft
Oxidation Ditches	2	Volume = 175,000 ft^3 SWD = 11ft
Final Clarifiers	2	Diameter = 80ft SWD = 15ft
RAS Pumps	3 (2+1)	2,100 gpm each
WAS pumps	2	75 gpm
Tertiary Filters	2	65x15 ft each Dual media – anthracite/sand
Chlorine Contact Tank	2	44X30X8
Sludge Thickening	2 Gravity Belt Thickeners	100 gpm each
Anaerobic Digesters	2	50 ft diameter, SWD – 25ft Volume – 49,000 ft^3 each
Belt Filter Press	1	2 m width

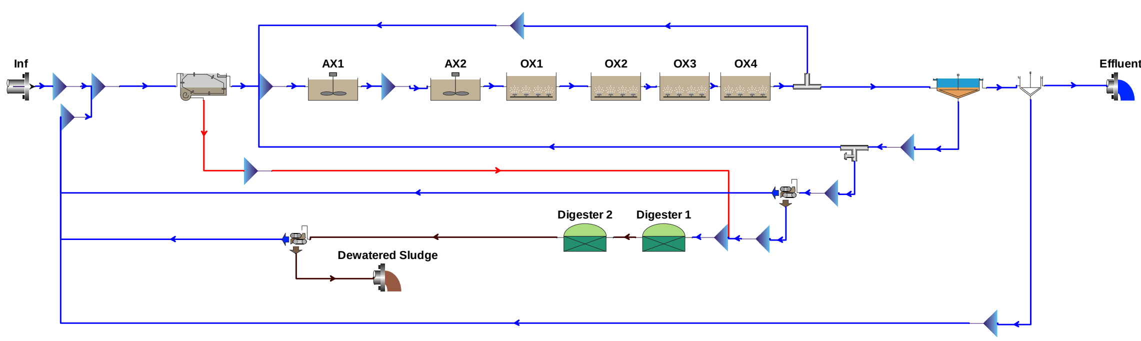


Figure ES3S.1 Sundog WWTP BioWin^{TM} Model Configuration Schematic

The Sundog WWTP BioWin^{TM} model was calibrated to match predicted values with the actual reported average annual and maximum month values of effluent ammonia, nitrate and nitrite concentration, volatile fraction of the MLSS, solids production in the waste activated sludge (WAS) stream, and digested solids production. The calibrated model predictions are in relatively good agreement with the plant data for average annual and maximum month conditions.

Overall plant capacity was determined considering the individual firm capacity of each individual unit process. The evaluation criteria of the individual unit processes are summarized in Table ES3S.7.

Table ES3S.7 Wastewater Treatment Process Units Evaluation Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Process Equipment Evaluation Criteria	
	Criteria	**Commentary**
Headworks	- Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows.
Primary Clarifiers	- Influent Flow	Maximum rated capacity was compared to peak daily or peak hourly flows
Tertiary Filters	- Hydraulic peak flows - Secondary effluent turbidity	Maximum rated capacity was compared to peak daily or peak hourly flows
Chlorine Contact Tank	- Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows
Belt Filter Press	- Digester Efficiency	Maximum rated capacity was compared to peak weekly solids production
Oxidation Ditches Final Clarifiers RAS Pumps WAS pumps Sludge Thickening Anaerobic Digesters	- Influent flow - Influent loads - Solids retention - Time (SRT) - Mixed Liquor Suspended Solids (MLSS)	BioWin™ Model

All unit processes were analyzed against the individual process evaluation criteria. Figure ES3S.2 presents the results of the capacity analysis. As shown, the secondary treatment process, filters and solids treatment/processing are limiting the existing plant capacity to 3.0 mgd compared to the 1990 upgrade project design capacity of 6.0 mgd. The difference is due to the drastic increase in wastewater strength over the last 20 years, most likely due to reduce water use and appliance efficiencies.

As part of the capacity analysis, a field investigation was conducted to assess periodic operating challenges to achieve complete denitrification.

The investigation consisted of DO and temperature profiling in addition to physical observations. In general, the major findings of the field investigation included identification of a flow split imbalance between ditch 1 and 2, the need for improved DO control and the need for testing the process response to polyaluminum chloride addition.

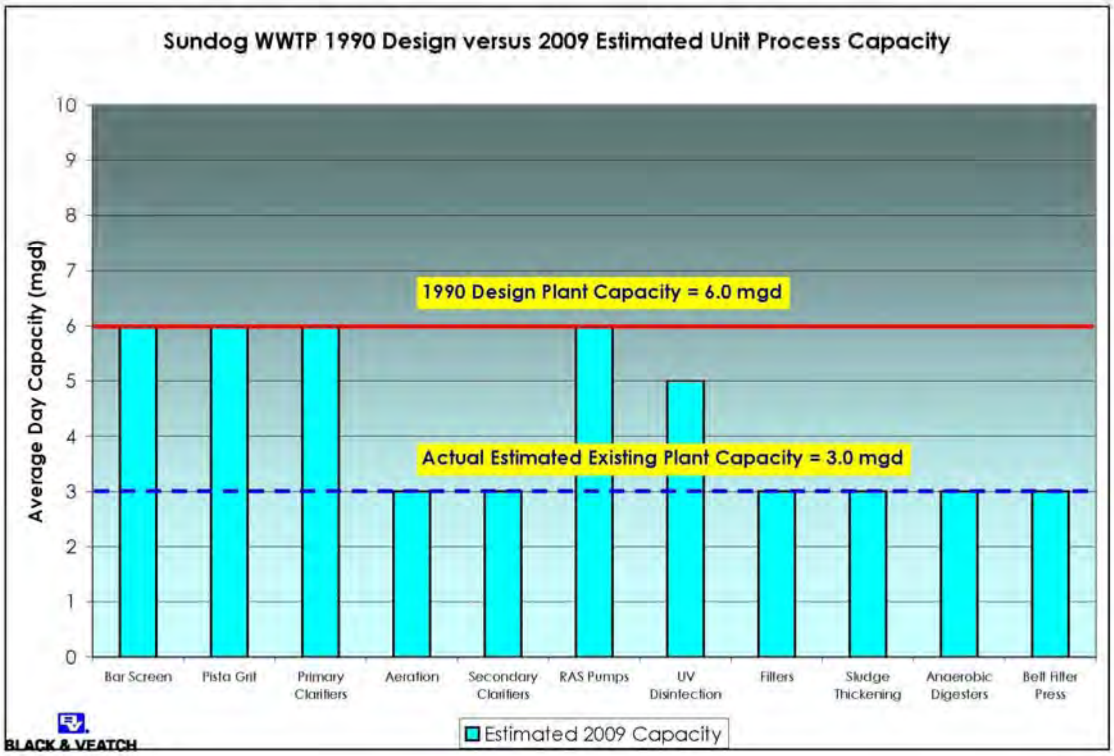


Figure ES3S.2 Sundog WWTP 1990 Design versus 2009 Estimated Unit Process Capacity

ES3S.5 Plant Issues, Needs and Operational Preferences

Based on the condition assessment, capacity evaluation and discussions with plant staff; several recommendations for each unit process were identified, as presented in Table ES3S.8.

Table ES3S.8 Unit Process Recommendations
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Unit Process	Recommendations
Headworks	• New Headworks facility to be coordinated with new Sundog Trunk Main. • Parshall flume sized for peak wet weather events equipped with ultrasonic level detector programmed for entire range of influent flows. • Redundant influent screens. • Screening washer/compactor to decrease operations and reduce odor and vector issues. • Multiple smaller vortex grit basins to handle the wide range of influent flows. • Integrated septage receiving station.
Primary Clarifiers	• Install sludge blanket level detectors for process control and procure hand held devices. • Filter the scum and meter to the anaerobic digesters in lieu of disposal to the drying bed.
Settled Sewage PS	• Install a check valve to prevent overflows to filtrate manholes.
Oxidation Ditches and Aeration Blowers	• Automated DO control for the aeration system to provide better process control and reduce filamentous growth. • Mechanical mixing to improve mixing within the anoxic zones. • Chlorine spray system to control surface foam in the oxidation ditches. • Chlorination of the RAS line. • Install launder or V-notch weirs in flow splitter. • Install VFDs on all brush rotors. • Install DO probes, 4 per ditch. • Install PLC for DO control. • Install submersible mixers.
Secondary Clarifiers	• Install sludge blanket level detector for process control. • Provide launder covers to reduce algae growth.

Table ES3S.8 Unit Process Recommendations Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona	
Unit Process	**Recommendations**
Tertiary Filters	• The existing traveling bridge filters have experienced failure of the underdrains and require rebuilding or replacement.
Disinfection	• Automated flow pacing and transmissivity control. • Install wiper system to maintain efficiency and improve lamp life. • Adjust effluent gate control to reduce cycling • Cover basins to reduce algae growth and prevent dust intrusion.
Solids Processing	• Rebuild the second GBT to provide redundancy. • Additional digester volume to meet the required 15 day HRT for Class B. • Digested sludge storage for 5 days per week sludge dewatering operations. • New dewatering equipment and facility.

In addition to the above unit process recommendations and the need for additional treatment capacity, the following additional plant components are recommended:

- New septage receiving facility.
- A grease receiving station.
- Stormwater flow equalization.
- Supervisory Control and Data Acquisition (SCADA) system for monitoring and control of plant process.

1.0 INTRODUCTION

1.1 Purpose

This technical memorandum is part of the Sundog WWTP and Airport WRF Capacity and Treatment Technologies Assessments for the City of Prescott. The purpose of this technical memorandum is to gather, organize, and document existing conditions for the Sundog WWTP, including available data, physical condition of existing facilities, existing treatment capacity, and operational issues. This memorandum will serve as the foundation for defining and developing the design for required near-term improvements at the Sundog WWTP. It will also serve as the existing condition reference point for long-term treatment technologies and capacity improvements.

1.2 Project Background

The City of Prescott is located in the mountains of north central Arizona, and borders the Prescott National Forest to the south and west. Prescott currently has three operating wastewater treatment facilities – Hassayampa WRP, Sundog WWTP and the Airport WRF. The Hassayampa WRP was placed into service in 1999, is privately operated and its effluent is used to water a private golf course. The City's largest wastewater treatment plant, the Sundog WWTP, is located approximately 2 miles northeast of the City's centroid, and currently receives the majority of the City's wastewater flow. It was last upgraded in 1990. The Airport WRF is located roughly 8 miles northeast of the City's centroid, adjacent (east) of the local airport (Ernest A. Love Field).

The existing Sundog WWTP was last expanded in 1990, and designed for a treatment capacity of 6.0 mgd AADF. The liquid treatment process was upgraded to include primary clarification, denitrification and filtration. The purpose of the process upgrade was to provide an effluent of suitable quality for irrigation of open-access turf sites and aquifer recharge by means of percolation recharge basins constructed near the Airport WRF under the same contract.

Prior to the 1990 expansion sludge from the Sundog WWTP was originally stored and dewatered in drying beds on-site. After completion of the expansion project including anaerobic digesters a sludge dewatering belt press was added in 1997. Class B dewatered sludge is disposed of at a land application site.

A site plan depicting the existing facilities at the Sundog WWTP is presented in Figure 1.1.

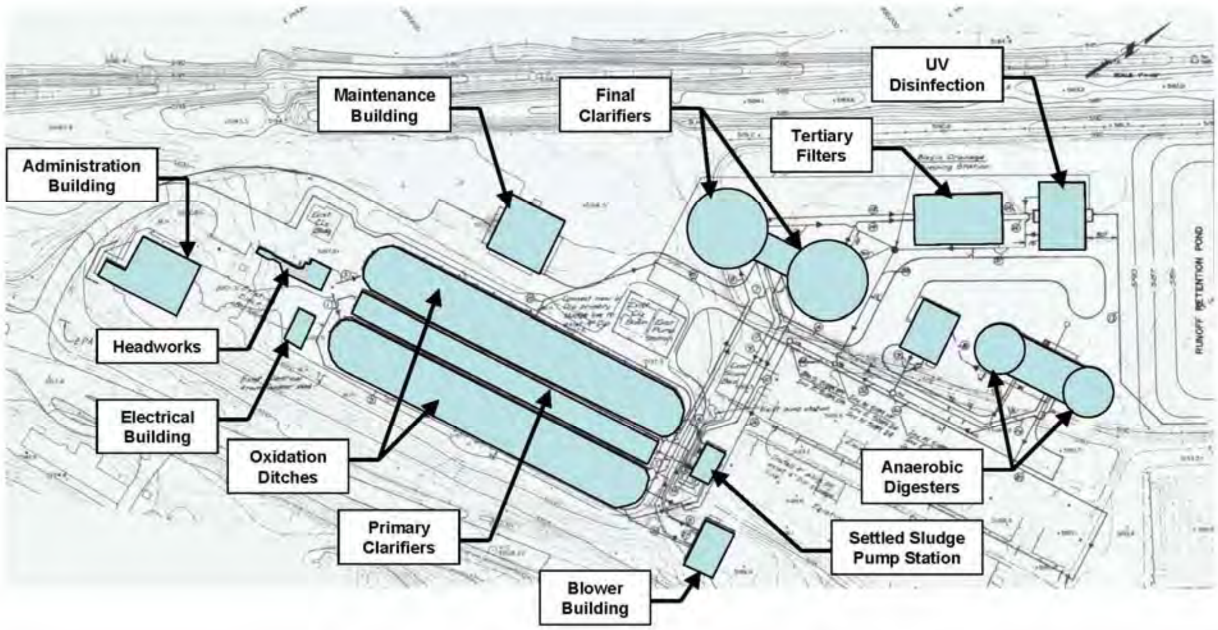


Figure 1.1 Sundog WWTP Site Plan Depicting the Existing Facilities.

2.0 EXISTING INFORMATION

2.1 Previous Design Documents

Several existing documents were gathered for the existing City of Prescott Sundog WWTP facility assessment:

- Sundog WWTP Improvements, Design Memorandum, Black & Veatch, 1988
- Sundog WWTP Improvements, Contract Specifications, Black & Veatch, 1989
- Sundog WWTP Improvements, Contract Drawings, Black & Veatch 1989
- Sundog WWTP Improvements, O&M Manual, Black & Veatch
- Sundog WWTP Various Process Data, City of Prescott, 2006-2009

2.2 Existing Facility Basis of Design

2.2.1 Hydraulic Criteria

Table 2.1 presents the hydraulic design capacity for the existing Sundog WWTP.

Table 2.1 Existing Hydraulic Design Flows
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	1990 Design
Annual average daily flow, mgd	6.0
Maximum month average daily (design) flow, mgd	6.5
Maximum day flow, mgd	12.0
Hydraulic capacity, peak (hour), mgd	15.0

2.2.2 Previous Wastewater Characteristics

The wastewater characteristics used for the previous 1990 expansion design were 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and Total Kjeldahl Nitrogen (TKN). The concentrations shown in Table 2.2 were based on historical plant records furnished by the City at the time of the design.

Table 2.2	Design Wastewater Characteristics and Concentrations Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona	
	Average	**Maximum Month**
Characteristics	**mg/L**	**mg/L**
BOD_5	152	166
TSS	165	171
TKN	24	30
Temperature, °C		
Summer	25	
Winter	10	

2.2.3 Governing Codes

The City of Prescott adopted the 2006 International Building Codes (2006 IBC), which became effective October 15, 2007. The 1990 expansion design effort was based on 1985 and 1987 codes. The previous and currently adopted codes are shown in Table 2.3.

Table 2.3 Governing Building Codes Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona	
Previous Design Governing Codes	**Current Governing Codes**
1985 Uniform Building Code	2006 International Building Code (IBC)
1985 Uniform Mechanical Code	2006 International Mechanical Code (IMC)
1985 Uniform Plumbing Code	2006 International Plumbing Code (IPC)
1987 National Electric Code	2006 International Electrical Code (IEC)

2.3 Existing Facilities

The 1990 improvements to the Sundog WWTP consisted of the following facilities:

- Headworks
  - Bar screens
  - Grit removal (vortex type)
- Primary Clarifiers
  - Conversion of existing final clarifiers
- Oxidation Ditches
  - Anoxic zones
  - Supplemental diffused aeration
  - Blower building
- New Circular Final Clarifiers

- Return Activated Sludge (RAS) Gravity fed to Screw Pumps
- Waste Activated Sludge (WAS) / Scum Pump Station
- Traveling Bridge Filter
- Chlorine Contact Basins
- Anaerobic Digestion WAS Thickening
- Sludge Dewatering Press

2.3.1 Headworks

The 1990 plant improvements project included modifications to the existing headworks. The headworks consists of one climber-type bar screen, one manually cleaned bar screen to serve as a bypass, a Parshall flume, and a vortex type grit removal basin with a grit dewatering screw.

2.3.1.1 Parshall Flume

An existing Parshall flume with a 18-inch throat width was left in place. The existing flume has a maximum flow limit of 10 mgd.

2.3.1.2 Bar Screens

One mechanical “climber” screen was installed for primary duty and one existing manually cleaned bar screen was retained for emergency bypass flows. Screenings are discharged to a trailer for landfill disposal. Design criteria for the existing screening facilities is presented in Table 2.4.

Table 2.4 Existing Screening Facilities Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Number	
Mechanical	1
Manual	1 (standby)
Clear space between bars, inches	3/4
Channel width, feet	4
Channel depth, feet	3.25
Depth of flow, maximum ft	2.75
Angle of screen inclination	80 degrees
Maximum velocity through screen at 15.0 mgd, fps	4.5
Average quantity of screenings, ft^3/day	8
Rake motor horsepower	1.5
Control	Local manual and auto control with repeat cycle timers and head differential override

2.3.1.3 Grit Removal

One vortex type grit removal unit is provided with a grit dewatering screw. The grit unit is designed to remove 95 percent of 50 mesh grit at peak hour flow (15 mgd). Dewatered grit is discharged from the screw to a front loading dumpster, along with screenings, for landfill disposal. A bypass channel is provided for the grit removal unit. Design criteria for the existing grit removal system is presented in Table 2.5.

Table 2.5 Grit Removal System Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Number	1
Type	Vortex type
Trap Zone	
Diameter, ft	16
Depth, ft	5.5
Storage Sump	
Diameter, ft	5.0
Depth, ft	6.8
Grit pump capacity, gpm	250
Motor hp	10
Average day grit removed, ft^3/day	8

2.3.2 Primary Clarifiers

The 1990 improvements project included converting two rectangular final clarifiers to primary clarifiers. Design criteria for the primary clarifiers is presented in Table 2.6.

Table 2.6 Primary Clarifier Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Number	2
Length, ft	145
Width, ft	30
Sidewater depth, ft	10
Average overflow rate, gpd/ft^2	690

2.3.3 Settled Sewage Pumping Station

The 1990 improvements project included a new settled sewage pumping station to lift primary effluent and RAS from the converted final clarifiers up into the oxidation ditches. Return activated sludge flows by gravity from the new final clarifiers to the settled sewage pumping station and is pumped to the oxidation ditches along with primary effluent.

Table 2.7	Settled Sewage Pumping Station Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Pump Type	Arcamedian screw
Number Pumps	3 (one stand-by)
Rated capacity, gpm	5,200
Maximum Lift, ft	7.75
Screw Diameter, inches	54
Screw Incline, degrees	38

2.3.4 Oxidation Ditches

The 1990 Sundog WWTP improvements project included modifications to the two existing oxidation ditches to 1) provide anoxic zones for denitrification and 2) supplemental diffused aeration to increase oxygen transfer capability for complete nitrification. With the addition of primary clarifiers to reduce organic loading and additional aeration, it was also possible to increase the rated treatment capacity of the existing oxidation ditch volume.

The plant operates in the nitrification/denitrification mode. Anoxic zones were created in each ditch by locating all existing brush rotors (4 each ditch) on one side of the ditch (relocating a total of three brush rotors and reversing rotation of the remaining eight). The supplemental diffused aeration was added between brush rotors concentrating all aeration on one side of each ditch. The unaerated side became the anoxic zone in each ditch. The brush rotors were intended to maintain flow velocity around the ditches sufficient for mixing energy.

The design criteria for the oxidation ditches is presented in Table 2.8.

Table 2.8	Oxidation Ditch Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Number	2
Total Volume, cu. ft.	350,000
Side water depth, ft	11
Hydraulic retention time,	9.7
hours at rated maximum month flow (6.5 mgd)	
Brush Aerators	
Number	4
Peak firm SOTR, pph	130
Motor hp, each	40
Diffused Aeration	
Type	Coarse bubble
No. Diffusers, each ditch	250

Table 2.8	Oxidation Ditch Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Air requirements, each ditch	
Average, scfm	2,200
Peak, scfm	6,000

2.3.5 Aeration Blowers

A new blower building was provided to house multi-stage centrifugal blowers for air supply to the supplemental diffused aeration system. The design criteria for the aeration blowers is presented in Table 2.9.

Table 2.9	Aeration Blower Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Number of blowers	4 (one stand-by)
Type	Multi-stage centrifugal
Rated capacity at maximum temperature and relative humidity, icfm	5,200
Rated inlet pressure, psi	11.9
Maximum temperature, F°	100
Maximum relative humidity, percent	36
Motor hp	150

2.3.6 Secondary Clarifiers

The design criteria for the circular secondary clarifiers is presented in Table 2.10.

Table 2.10	Secondary Clarifiers Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Number	2
Diameter, ft	80
Sidewater depth	15
Bottom slope	1:12
Overflow rate, max month gpd/sq ft	647
Peak solids loading rate, lb/day/sf	25
Max month detention time w/o recycle, hrs	4.16
Flocculation well	
Diameter, ft	34
Skirt depth below water, ft	8
Number of flocculators	4
Velocity gradient "G"	50
Motor hp	2
Sludge Collectors	
Motor hp	2

2.3.6.1 Return and Waste Sludge and Scum Pump Station

A sludge and scum pump station is located between the two final clarifiers and provides the following functions:

- Metering and control of return activated sludge flow by gravity from the final clarifiers to the settled sewage pump station. The settled sewage pumps lift return activated sludge along with primary clarifier effluent into the oxidation ditches.

- Controlled pumping of waste activated sludge from the final clarifiers to the gravity belt thickeners.

- Pumping scum collected from the surface of the final clarifiers to the oxidation ditches via the settled sewage pump station or the anaerobic digesters.

Design criteria for the return and waste sludge and scum pump station is presented in Table 2.11.

Table 2.11	Return and Waste Sludge and Scum Pump Station Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Return Activated Sludge	
Number of return lines	2
Gravity flow control	Magnetic flow meters and modulating valves
Maximum flow rate set each, mgd	3.0
Waste sludge pumps	
Number of pumps	2
Type	Rotary lobe
Rated capacity, gpm	75
Rated head, ft	21
Motor hp	5
Waste scum pumps	
Number of pumps	2
Type	Rotary lobe
Rated capacity, gpm	125
Rated head, ft	21
Motor hp	5

2.3.7 Tertiary Filters

The 1990 plant improvements project included addition of tertiary filters. The tertiary filters design criteria is presented in Table 2.12.

Table 2.12	Tertiary Filters Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Filters	
Type	Traveling bridge continuous backwash
Number	2
Length, ft	70
Width, ft	16
Total area, sq ft	2,240
Hydraulic loading rate, @ 6 mgd, gpm/sq ft	2.0
Media type	sand, 0.45 to 0.55 mm anthracite, 0.75 to 0.85 mm
Nominal media depth, inches	12” sand 12” anthracite

2.3.8 Disinfection System

The 1990 plant improvements project included addition of two new chlorine contact basins. In 2002 an ultraviolet disinfection system was installed in one of the chlorine contact basins with the other basin remaining intact to provide for chlorine contact disinfection as a backup to the UV system.

The UV system was designed for a peak hydraulic capacity of 10 mgd with a suspended solids concentration of 5 mg/L. The UV system was also designed to meet the 1985 reuse standard for irrigation of turf areas with open access (5 fecal coliform sample geometric mean of less than 25 cfu/100 mil). The 1985 water reuse standards were replaced by the Arizona Department of Environmental Quality (ADEQ) APP with updated water reuse categories and standards in 2001.

Design criteria for the 1990 chlorine contact basins and the 2002 UV system are presented in Table 2.13.

Table 2.13 Disinfection Facilities Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

1990 Chlorine Contact Basins (1985 Standards -25)	
No. of basins	2
Length, ft	44
Width, ft	33
Channel width, ft	6
Sidewater depth, ft	8
Volume each basin, ft^3	10,512
Theoretical detention time @ peak flow (15 mgd), min	15
Rapid mixing detention time, sec	15
Mixing velocity gradient “G”, sec^{-1}	500
2002 Ultraviolet Disinfection System (2001 Class B)	
Number of channels	1
Channel dimensions, L x W x D, ft	36 x 4.67 x 4
Depth of flow, ft	2.3
Peak design flow, mgd	10
Type of system	Low pressure / high intensity
No. of banks	2
No. of lamps per bank	128 horizontal
Percent UV transmittance	65
UV dosage, $cuWs/cm^2$	47,606

2.3.9 Sludge Treatment and Handling

Sludge handling and treatment facilities include waste activated sludge thickening, anaerobic digestion of combined primary sludge and thickened waste activated sludge and dewatering of digested sludge. Dewatered sludge is disposed of via land application. Design sludge production criteria is presented in Table 2.14.

Table 2.14 Sludge Production Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Primary Sludge @ 4% solids	
Average annual production, ppd	4,954
Maximum month production, ppd	5,562
Waste Activated Sludge @ 0.5% solids	
Average annual production, ppd	3,780
Maximum month production, ppd	4,540

2.3.9.1 Sludge Thickening

Two gravity belt thickeners (one standby) are used to thicken waste activated sludge prior to anaerobic digestion. Currently, one unit runs, continuously as the second is not in service. Thickened sludge pumps deliver thickened sludge to the anaerobic digesters. Design criteria for the gravity belt thickeners is presented in Table 2.15.

Table 2.15 Waste Activated Sludge Thickening Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Number of thickening units	2 (one stand-by)
Type	Gravity belt
Hydraulic capacity, gpm	100
Maximum solids loading, lb/day	4,540
Belt width, meters	1
Thickened sludge pumps	
Number	2
Type	Progressing cavity
Rated capacity, gpm	50
Normal pressure range, psi	8-12
Motor hp	5

2.3.9.2 *Anaerobic Digester*

Two anaerobic digesters operating in series are provided with a fixed cover primary digester and a floating cover secondary digester. Piping and equipment are provided and configured so the secondary digester can serve as a standby primary digester.

Design criteria for the anaerobic digesters and support facilities is presented in Table 2.16.

Table 2.16 Anaerobic Digester Design Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Number of digesters		2	
Diameter, ft		50	
Sidewater depth, ft		25	
Volume each, ft^3		49,000	
Primary digester max month SRT, days		12.1	
Primary digester max month volatile solids loading, ppd/1000 ft^3		163	
Average gas production, ft^3/day		53,800	
Gas heat value, MBtu/day		32.3	
Max month heat required, MBtu/day		12.9	
Digester mixing			
Type		Draft tube mechanical mixes	
Number circulating capacity per unit, gpm		7,600	
Motor hp		5	
Sludge heaters			
Type		Combination boiler/heat exchanger	
Number		2 (1 standby)	
Boiler rating, MBtu/hr		1.0	
Exchanger capacity, MBtu/hr		0.5	
Sludge recirculation pumps	SRP-1	SRP-2	SRP-3
Number	2	1	1
Type	Centrifugal Grinder	Centrifugal Grinder	Centrifugal Grinder
Rated capacity, gpm	145	300	145
Rated head, ft	13	50	50
Motor hp	3	7.5	10
Digester sludge pumps			
Number		2	
Type		Progressing cavity	
Rated capacity, gpm		100	
Pressure range, psi		2-5	
Motor hp		7.5	

2.3.9.3 Sludge Dewatering

Shortly after completion of the 1990 improvements, the City purchased and installed one belt dewatering press in a temporary mobile unit. A permanent belt press facility was included in the 1990 project design, but was postponed for budget reasons. Design criteria for the belt dewatering press is presented in Table 2.17.

Table 2.17	Belt Press Design Criteria Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona
Number of units	1
Belt width, meters	2
Polymer	Dry system
Batch tanks	2
Volume, gals	350
Metering pumps	1

2.3.10 Septage Receiving Station

The Sundog WWTP includes a septage receiving station that was constructed with the original plant in 1934. The station originally included pumps and an inline grinder to meter septage into the plant over time. The pumps and grinder have been decommissioned and the station currently consists of a manually cleaned bar rack, a pit and a gravity pipe connection directly in to the plant influent sewer.

2.3.11 Standby Power

A 300 kW diesel engine powered generator provides emergency power for selected plant equipment. The generator is designed to power the grit removal equipment; 2 primary sludge pumps; 4 oxidation ditch rotors; 2 settled sewage pumps; 2 final clarifier sludge collectors, mixers and rotating scum pipes; and 2 anaerobic digester sludge recirculation pumps.

There is natural gas service to the site.

2.4 Existing Facility Permits

As presented in Technical Memorandum #1 – “Regulatory, Compatibility and Reliability Requirements,” the Sundog WWTP was designed to produce reclaimed water suitable for irrigation of “areas open to public access” under the 1985 Regulations for the Reuse of Wastewater. The plant currently operates under Aquifer Protection Permit (APP) No. P-100353 which permits the facility for Class B+ effluent. Moving forward, process evaluation and master planning will be based on technologies capable of producing ADEQ Class A+ reclaimed water. These water quality standards are shown in Table 2.18.

Table 2.18 ADEQ Reclaimed Water Quality Standards
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Parameter	Treatment Standards	
	Existing Class B+	Future Class A+
Turbidity, NTU		
Average	NA	2
Single Sample Maximum	NA	5
Fecal Coliform, cfu/100mL		
4 of last 7 samples	200	Non-detect
Single Sample Maximum	800	23
Total Nitrogen Alert Level, mg/L		
5 samples geometric mean	8	8

3.0 PHYSICAL CONDITIONS

3.1 Site Survey

The original coordinate system for the Sundog WWTP used the Arizona State Plane coordinate system. Specific coordinates to be used for horizontal control were listed on the 1988 Black & Veatch plans.

The project benchmark was based on a brass cap set on USGS benchmark M-27 located on Oxidation Ditch 1 walkway. The project benchmark elevation was determined to be 5197.48 based on the City of Prescott Datum.

The 100-year flood elevation had not yet been determined for the area.

It is recommended that a new survey be conducted to update/verify the horizontal and vertical control prior to any new work at the plant. The new survey will adhere to the Layer and Survey Datum Requirements memorandum (Appendix B) from the City of Prescott. Datum will be in international feet for horizontal and vertical, NAVD 88 for vertical and City of Prescott coordinates for horizontal. A new permanent benchmark should also be established to provide a consistent survey control point for work at the site.

3.2 Geotechnical Conditions

A geotechnical site investigation was performed in 1988 by Gellhaus Engineering and Testing Laboratories. Subsurface soil borings were drilled at the location of the new facilities constructed in 1988. Borings were generally drilled a minimum of five feet into firm foundation soil satisfactory for supporting the proposed loadings. Groundwater was not encountered in any of the test holes to the depths drilled.

The existing soil conditions are a mixture of sandy clay (SC) and gravelly clay (GC). Soft fill soils were encountered throughout the site. Overexcavation of the soft soils was required for the structure foundations. The depth of the overexcavation was dependant on the location of the structure. All excavations were properly sloped as necessary to satisfy local safety code regulations and provide individual protection.

The foundations bearing on approved undisturbed soils may have been designed for an allowable bearing pressure of 1,000 or 2,000 psf depending on location. Excavations in the area of the filters and chlorine contact basin yielded lower allowable bearing pressures. Consolidation settlement anticipated to be negligible under the proposed loading. Settlements in the fill locations may have been slightly greater than settlements in the naturally undisturbed soils but would have been negligible if proper procedures for site grading and compaction were followed. Poor drainage conditions could have resulted in localized settlement.

It is recommended that a new geotechnical investigation be conducted to update/verify the subsurface conditions prior to any new work at the plant. The geotechnical investigation will take into account the location of new structures.

3.3 Equipment and Structure Condition Assessment

A site visit was conducted on June 8, 2009 to assess the current condition of the existing equipment and structures at the Sundog WWTP. The intent of the inspection was to document the general condition of all major equipment and structures at the plant, to provide input for future improvements planning. The structural inspections were limited to the interior surfaces of walls above the waterline. Similarly, mechanical inspections were limited to equipment components above the waterline. This visual inspection did not include functional tests, core sampling, or other detailed tests, and was limited to a general visual assessment of the condition of equipment and structures at the WWTP.

3.3.1 Headworks

The existing headworks concrete structure is in good condition. The influent screen and grit basin equipment exhibit some minor corrosion and wear on moving parts. A hydraulic baffle plate has been installed within the channel just upstream of the grit basin by the vendor, apparently to improve system performance.

3.3.2 Primary Clarifiers

The plant staff stated the existing nonmetallic (HDPE) chain and flight sludge collection system operates well with little operator attention required. The weirs show signs of corrosion and are beginning to come apart from the launders. The primary sludge pumps have experienced several diaphragm and bearing failures. The pumps are nearing the end of their life cycle and exhibit signs of heavy corrosion.

3.3.3 Oxidation Ditches and Aeration Blowers

The area along the northeast corner of the oxidation ditches show signs of settlement of exterior fill as shown in Figure 3.1. Additional concrete and asphalt pavement have been added to resolve the issue. Although the basins appear to be structurally sound, further settlement could undermine the structural integrity.

Figure 3.1 Settlement Along NE Corner of Oxidation Ditch

The mounts for the brush rotors and gear box show significant concrete failure. The support mounts for the gear box appear to be installed to close too the edge resulting in concrete failure as shown in Figure 3.2. Plant staff have fabricated and installed additional structural supports to resolve the issue. The vibration of the rotors has resulted in the cracking of the concrete bases. The rotors are mounted directly to the concrete without any vibration damping mechanism.

Figure 3.2 Oxidation Ditch Concrete Failures

3.3.4 Secondary Clarifiers

The secondary clarifier basins appear to be in good structural condition. The #2 clarifier drive mechanism experienced occasional bearing failures (2) with the gear box requiring replacement. The second clarifier drive mechanism is beginning to exhibit similar symptoms and may need replacement in the near future. The existing WAS and scum pumps perform well and only one of the original pumps have been replaced due to failure.

3.3.5 Tertiary Filtration

The existing underdrains for the traveling bridge filters have failed and are in need of replacement. A full assessment of the current condition of the traveling bridge filters is detailed in TM7 Tertiary Filtration Evaluation.

3.3.6 Disinfection

The existing chlorine contact concrete basin is in good condition. The UV disinfection equipment is in good condition with little sign of wear. No significant issues were located during the tour.

3.3.7 Solids Processing

Two gravity belt thickeners were originally installed in the Solids Processing Building. One of the units has been stripped of parts to maintain the other unit in operation. The frame and remaining parts of this unit are in good condition and can be placed back into operation once the missing parts are replaced.

A single belt filter press is located in a prefabricated metal building adjacent to the digesters. The building lacked appropriate ventilation and corrosion protection resulting in severe siding and structure damage to the building structure as shown in Figure 3.3. The belt filter press itself shows signs of corrosion and heavy equipment wear. The existing belt is misaligned creating operational issue. The belt and rollers have heavy struvite accumulations as shown in Figure 3.4. Additionally, the unit shows significant signs of rotting and is at the end of its useful life. The unit will not continue to operate in the long term.

Figure 3.3 Belt Filter Press Building

Figure 3.4 Struvite on BFP Belt and Rollers

4.0 CAPACITY ANALYSIS

4.1 Background

The primary objectives for modeling the performance of the Sundog WWTP is to evaluate the performance of the existing facilities under current and future loadings, in order to determine the current treatment capacity of the existing facilities.

One of the key first steps in ensuring accurate simulation results is confirming the influent wastewater characteristics and loadings. This memorandum summarizes the current influent wastewater flows and characteristics to be used for the process evaluation under existing conditions.

4.2 Wastewater Flows

Daily average, high, and low influent flows were obtained from plant operational data records between January 2006 and April 2009. The average daily flow into the plant has slightly increased over time. Throughout a calendar year, the plant typically receives higher flows during winter months, as a result of infiltration and inflow during wet weather months (although the summer of 2007 was particularly wet). A graph with the historical flow data analysis and the recommended peaking factors for maximum month and maximum day is presented on Figure 4.1.

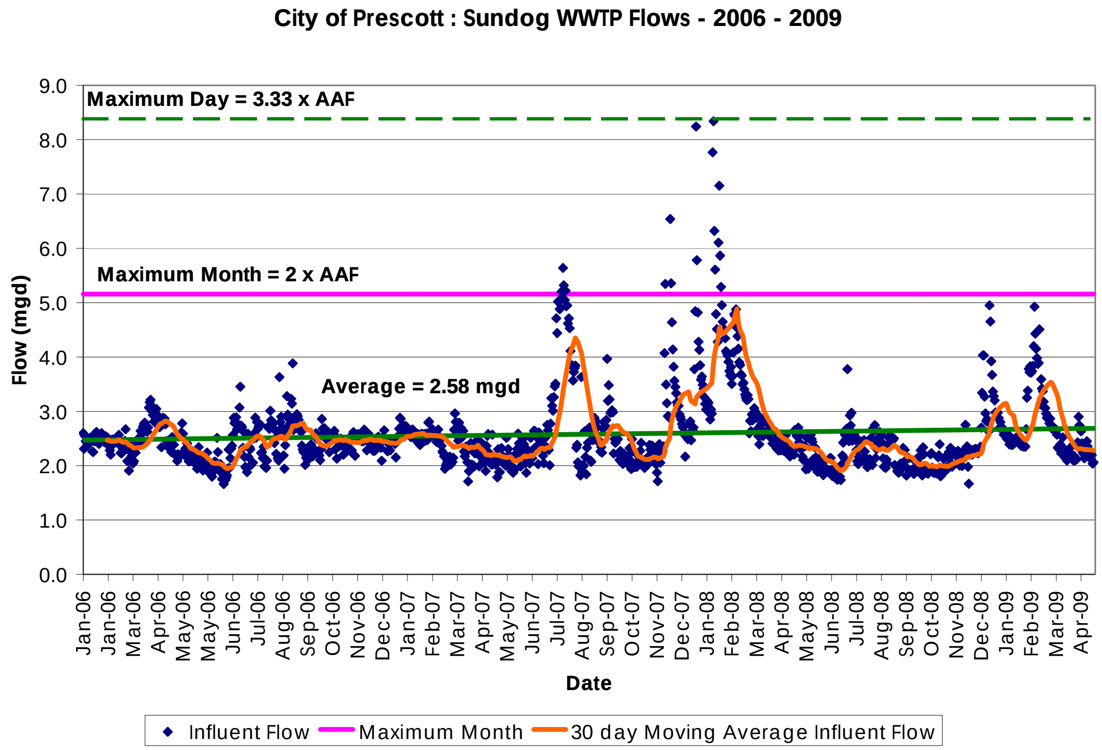


Figure 4.1 Sundog WWTP Flows, Maximum Month and Day Peaking Factors

The recommended maximum month flow peaking factor was based on the ratio between the maximum 30-day running average flow and the annual average day flow. A linear regression was used to calculate the annual average flow over the entire period of data analysis. The peak day factor was based on the ratio between the maximum daily average flow and the annual average flow.

A graph illustrating the maximum hour peak flow factor is presented in Figure 4.2.

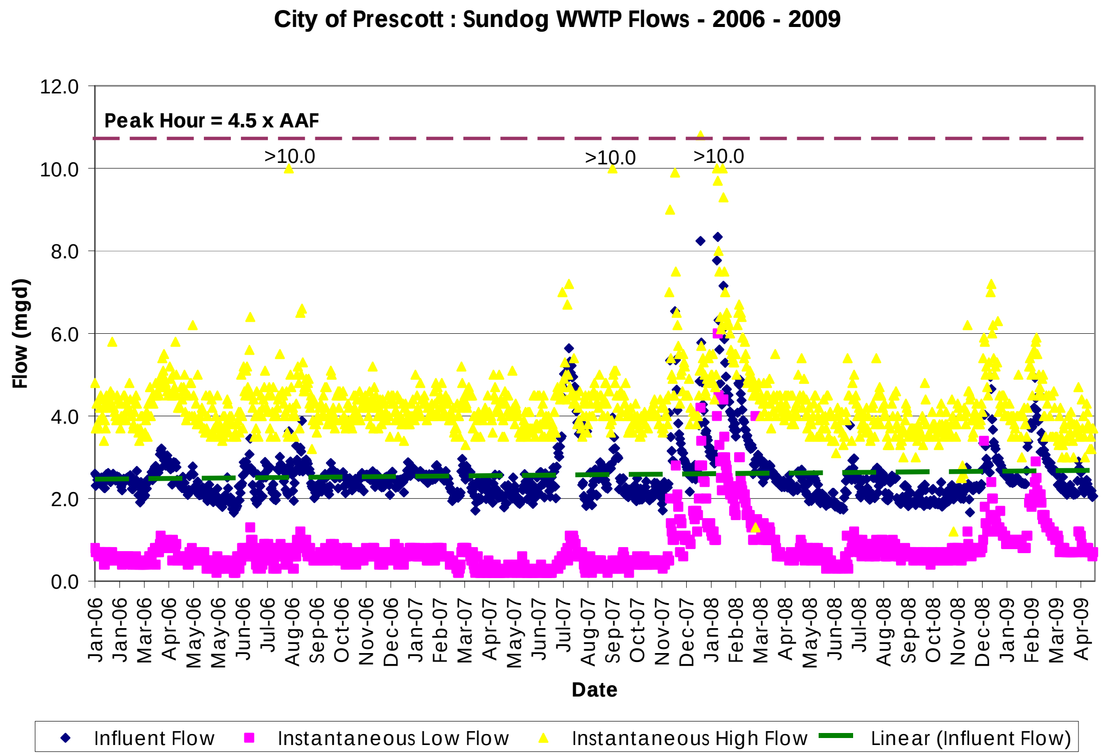


Figure 4.2 Sundog WWTP Flows, Maximum Hour Peaking Factor

The peak hour factor was based on the ratio between the maximum high flow reported and the annual average day flow. The recommended peaking factors are presented in Table 4.1.

The Sundog WWTP influent flow meter does not read above 10.0 mgd, and on several occasions the influent flow meter pegged out at 10 mgd. The true maximum hour peaking factor is unknown, but likely significantly exceeds 4.0.

Table 4.1	**Design Hydraulic Peaking Factors Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona**
Average Annual Flow (mgd)	2.58
Hydraulic Peaking Factor	
Maximum Month : Average Day	2
Peak Day : Average Day	3.3
Peak Hour : Average Day	4.5

Based on historical data analysis between January 2006 and April 2009. All peaking factors presented in Table 4.1 are relative to the annual average day flow.

4.3 Wastewater Influent Characteristics

The current wastewater characteristics for the plant capacity analysis were determined based on an analysis of the plant's historical wastewater quality records. Influent characteristics were obtained from plant operations historical records between 2006 and 2009. Analysis of the influent to Sundog WWTP is complicated by the operation of the Hassayampa WWTP. This is a privately operated scalping plant and its effluent is used to water a private golf course during dry periods. The sludge produced at the WWTP is discharged to Sundog WWTP year-round, however the discharge of sludge is not necessarily continuous. In addition treated effluent from Hassayampa WWTP is discharged to Sundog when irrigation is not required at the golf course, or if excess irrigation water is available. Therefore influent flows and loads are highly variable. The highly variable operation of the Hassayampa WWTP on influent flow and loads is significant. In Summer, reduced influent flow at Sundog (due to scalping at Hassayampa) coupled with the intermittent sludge discharge could result in significant swings in influent TSS and BOD concentrations. In Winter, intermittent sludge discharge will also produce swings in influent TSS and BOD. Finally, the solids discharged from Hassayampa are activated sludge WAS. WAS is expected to contain ammonia oxidizing microorganisms that will appear to increase BOD values unless an inhibitor is used in the laboratory test. The characteristics of WAS will also skew volatile solids content of the influent TSS.

Therefore a statistical approach was taken in evaluating the influent loads of BOD and TSS. The approach was as follows:

1. A median value was calculated for the entire BOD and TSS concentration dataset for the period January 2006 to April 2009.

2. A standard deviation was calculated for the entire BOD and TSS concentration dataset.

3. The dataset was filtered so that influent BOD and TSS concentrations that exceeded the (Median value + 2 times the standard deviation), or were less than the (Median value – 2 times the standard deviation) were deleted from analysis.

4. The filtered influent BOD and TSS loads were then calculated by multiplying filtered BOD and TSS concentrations with flow.

So, all BOD concentrations exceeding 678 mg/L and less than 63 mg/L were filtered, and all TSS concentrations exceeding 1,012 mg/L were filtered.

Composite samples of the plant influent are taken at the headworks, after the wastewater goes through screening and grit removal. Flow and characteristics from the tertiary filter backwash stream and sludge dewatering equipment are not routinely measured, but these recycle streams are diverted directly to the downstream aeration basin and do not impact the influent samples.

The following wastewater quality data provided by the City was used which resulted in the average influent wastewater characteristics presented in Table 4.2.

- **Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS):**

  Approximately four samples per month (one per week). Data was analyzed for the period between January 2006 and April 2009.

- **Total Kjeldahl Nitrogen (TKN) and Ammonia Nitrogen (N):**

  The TKN and NH_3-N values above are primarily grab samples, however, some composites were taken in 2007, 2008 and 2009. The total numbers of samples analyzed are 32 for TKN and 37 for NH_3-N.

Table 4.2 Average Influent Wastewater Characteristics
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	2006	2007	2008	2009	2006 – 2009[1]
BOD_5 (mg/L)	476	393	374	238	373
TSS (mg/L)	506	433	536	349	402
TKN (mg/L)	34.2	49.0	44.9	43.2	39.5
NH_3-N (mg/L)	27.6	38.6	32.9	31.2	31.5

[1] 2006-2009 data were filtered.

The average BOD concentration for the Sundog WWTP is within the typical range of values observed for other facilities in Arizona. For example the average influent BOD_5 measured in a neighboring facility for the period January 2007 to June 2009 was 341 mg/L.

The average influent TSS is still relatively high compared to other facilities in Arizona. For example the average influent TSS measured in a neighboring WWTP for the period January 2007 to June 2009 was 279 mg/L. The observed average TSS to BOD ratio of 1.08 is within the normal range of 1.0 – 1.2. The original design BOD to TSS ratio was 1.12.

The recommended wastewater characteristics for capacity were based on determining wastewater concentrations under annual average day loadings and maximum month loadings. Average loadings were based on average wastewater concentrations calculated over the entire analysis period (2006 to 2009). The maximum month loadings were based on calculating a 92nd percentile of the entire analysis period and reporting this value as the maximum month condition. The 92nd percentile value was selected as the maximum month using a simple assumption that 1 month in 12 months is approximately 8% therefore, the maximum month is 100% - 8% = 92nd percentile. In addition, a running 30 day moving average of the weekly influent loads was also calculated and the maximum 30 day running average was reported.

Table 4.3 presents the recommended maximum load peaking factors.

Table 4.3 Average Influent Wastewater Loading, pH and Temperature
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Parameter	Average	Running 30 day average Max Month	92 Percentile Max Month	92 Percentile: Average Peak Factor
BOD_5 (ppd)	7,563	11,839	10,498	1.39
TSS (ppd)	8,335	13,239	13,273	1.59
TKN (ppd)[1]	793.1	[1]	1,181	1.49
NH3-N (ppd)[1]	642.7	[1]	871	1.36
Variable	**Average**	**Range**		
pH	7.7	7.4 – 8.3		
Temperature (c)	19.6	13.8 – 26.2		

[1] – Insufficient N data to calculate running 30 day averages

Temperature, as shown in Figure 4.3 was based on the plant-reported values sampled from the influent. Process temperature is a critical parameter for the capacity evaluation of the secondary treatment system.

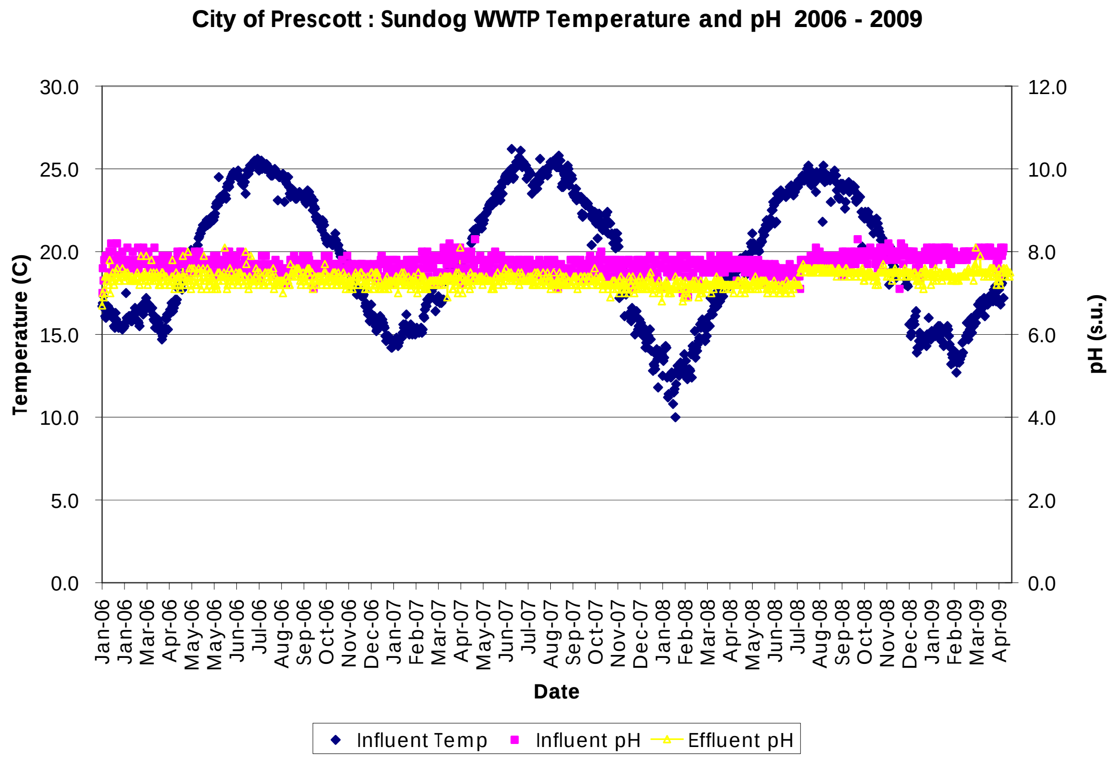


Figure 4.3 Sundog WWTP Influent Temperature and pH 2006 to 2009

The seasonal maximum month flow and maximum month concentration data at Sundog WWTP are not coincident. During high flow conditions (typically winter), the influent concentrations are diluted, during average flow conditions concentrations can be elevated due to tourism and other factors. Therefore two seasonal maximum load conditions were estimated. Table 4.4 represents the recommended wastewater concentration characteristics at average annual, and maximum month summer and maximum month winter conditions. The winter maximum month load is based on the average concentration at maximum flow. These will be used for the existing Sundog WWTP capacity evaluation.

Table 4.4	Current Wastewater Influent Loadings Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona				
Parameters	**Average (mg/L)**	**92%ile Max Month (mg/L)**	**92% Max Month: Average Annual Peak Factor**	**Summer Max Month Load (ppd)**	**Winter Max Month Load (ppd)**
BOD_5	390	608	1.56	2.58x608x8.34= 13,082	2.58x2x390x8.34= 16,783
TSS	418	676	1.62	2.58x676x8.34= 14,545	2.58x2x418x8.34= 17,988
TKN	39.5	57	1.39	2.58x57x8.34= 1,226	2.58x2x39.5x8.34= 1,700
NH3-N	31.5	48.8	1.52	2.58x48.8x8.34= 1,050	2.58x2x31.5x8.34= 1,356

Note: The winter peak load used for evaluation purposes is 30/38% higher than the maximum month load measured in 2006/2009. The reason for this anomaly is to account for the extremely high winter loads measured in 2006/2007.

The current existing wastewater concentrations are significantly higher than the criteria used for the original design of the secondary treatment facilities. Table 4.5 summarizes the comparison between the original design criteria and current existing conditions, as it pertains to influent wastewater concentrations. The existing BOD and TSS wastewater concentrations are higher than the original design criteria values by up to 4.0 times.

Table 4.5 Current Influent Wastewater Concentrations Compared with 1990 Design Values
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Existing Conditions		Current Conditions (1990)	
	Average	**Max Month**	**Average**	**Max Month**
BOD_5 (mg/L)	373	608	152	166
TSS (mg/L)	402	676	165	171
TKN (mg/L)	39.5	57	N/A	N/A
NH_3-N (mg/L)	31.5	48.8	24	30

Table 4.6 summarizes the comparison between 1990 design values and current existing conditions, as it pertains to influent wastewater mass loadings. Mass loadings are the product of flow and concentration and ultimately determine the loadings to the secondary system. The average influent flows are 43% of the original design values. However, the average BOD and TSS mass loadings are approximately the same as the 1990 average load. The maximum month loadings are almost 100 percent higher than the original maximum month design values. The design average and maximum month NH_3-N loads are also higher than the existing conditions.

Table 4.6 Current Influent Wastewater Flow and Load Compared with 1990 Design Values Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona				
	Current Conditions		**Design Conditions (1990)**	
	Average	**Winter Max Month**	**Average**	**Max Month[1]**
Flow (mgd)	2.58	5.16	6	6.5
BOD_5 (ppd)	7,563	16,783	7,606	8,999
TSS (ppd)	8,335	17,988	8,557	8,945
NH_3-N (ppd)	678	1,355	1,200	1,626

[1] – Maximum month load for the 1988 design condition was calculated assuming maximum month flow and concentration were coincident.

4.4 Wastewater Simulation Model Constants and Model Configurations

4.4.1 Capacity Evaluation Model

A process model (BioWin™) was used to evaluate the treatment capacity of the Sundog WWTP. The process model simulates the plant performance based on inputs for flow, loading, and other operating conditions. The model uses kinetic and stoichiometric parameters for calculating outputs. Outputs from the model are process effluent characteristics, process safety factors on achieving given criteria, or the allowable loading to prevent process failure. The model also generates projections for biosolids production, oxygen utilization, etc., that can be used to size auxiliary facilities (e.g., blowers, pumps, etc.)

4.4.2 BioWin™ Simulation Model Configurations

Table 4.7 Wastewater Treatment Process Units for Modeling
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Existing Process Equipment	
	Number	**Parameters**
Primary Clarifiers	2	Area = 4,350 ft^2 each SWD = 10ft
Oxidation Ditches	2	Volume = 175,000 ft^3 SWD = 11ft
Final Clarifiers	2	Diameter = 80ft SWD = 15ft
Screw Pumps (RAS)	3 (2+1)	2,100 gpm each
WAS pumps	2	75 gpm
Tertiary Filters	2	65x15 ft each Dual media – anthracite/sand
Chlorine Contact Tank	2	44X30X8
Sludge Thickening	2 Gravity Belt Thickeners	1 m width
Anaerobic Digesters	2	50 ft diameter, SWD – 25ft Volume – 49,000 ft^3 each
Belt Filter Press	1	2 m width

The BioWin™ model was configured to simulate the existing unit processes at the Sundog WWTP as summarized in Table 4.7. The BioWin™ model schematic is shown in Figure 4.4.

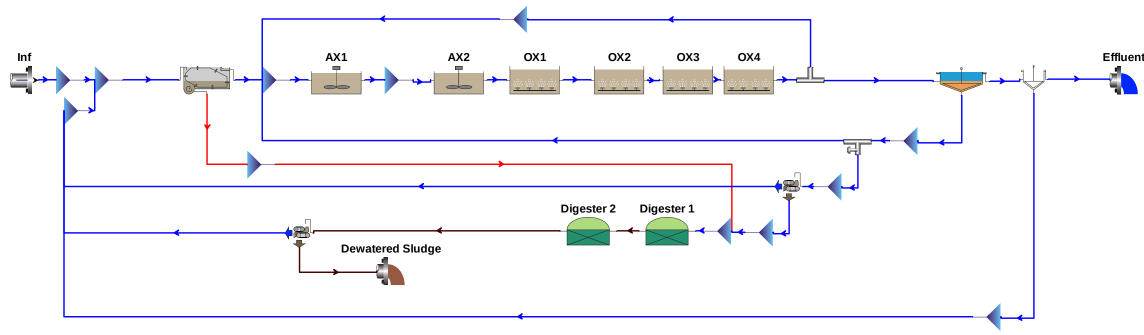


Figure 4.4 Sundog WWTP BioWin™ Model Configuration Schematic

4.4.3 BioWin™ Model Calibration

BioWin™ is a COD based mass balance approach using physical and biological models to simulate interactions between the different unit processes in a wastewater treatment facility. This means that the mass balance that is calculated is designed to balance the COD (not BOD_5 or TSS). Therefore adjustments and assumptions have to be made to utilize the BOD_5 and TSS values typically measured in conventional wastewater treatment. In addition, BioWin™ has over 200 kinetic, stoichiometric, settling, biofilm and other constants or factors that can be adjusted to calibrate model. These factors and the default values are provided in Appendix A. Typically the default values are used for almost all of these constants/factors in most simulations of WWTPs. However some key factors need to be calibrated for the model to represent a specific WWTP.

The following model influent characteristics were estimated based on Sundog WWTP influent data available and model calibration feedback data.

Table 4.8 Influent Wastewater Concentrations for Simulation Modeling
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Parameter	Model Input		
	Max Month Winter	**Max Month Summer**	
Flow (mgd)	5.16	2.58	
BOD_5 (mg/L)	390	608	
TSS (mg/L)	418	676	
TKN (mg/L)	39.5	57.0	
NH_3-N (mg/L)	31.5	48.8	
Temperature C	12.4	20	
Alkalinity (mg/L as $CaCO_3$)	295	295	
BioWin™ COD Fractionation			***Commentary***
COD (mg/L)	893	1,374	2 – 2.3 x BOD_5 typical
Readily biodegradable COD (%)	18.8%	19%	20% default
VFA fraction of COD (%)	15%	15%	15% default

The approach used for model calibration was to incorporate the available plant data as inputs to the model, and compare the steady state model predictions with annual average and maximum month plant data. The annual average influent BOD_5, TSS, TKN, NH_3-N values were used as inputs for the model calibration. Graphs of process data used in the model calibration procedure are included in Appendix A. In addition an sludge volume index (SVI) value of 175 mL/g was used for modeling secondary clarifier capacity. The historical median SVI at the Sundog WWTP is actually 190 mL/g. The reason for the high SVI is the proliferation of *Microthrix parvicella*, a known foaming and bulking filament in the MLSS[1]. A first step for Sundog WWTP is to control this filament using established techniques; therefore a more reasonable SVI was selected.

For the Sundog WWTP, the following factors were adjusted based on actual plant data.

[1] Michael Richard Wastewater Microbiology LLC. Microscopic Examination Results for Sludge Samples Dated 3/30/09. March 31, 2009

Table 4.9 Simulation Model Constants Adjusted Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona		
	Simulated Conditions	
	Default	**Adjusted**
Settling Parameters	5.16	2.58
Maximum Vesilind Settling Velocity (Vo) – m/d	170	156
Vesilind hindered zone settling parameter (K) – L/g	0.37	0.44
Clarification Switching Function – mg/L	100	20
Specified TSS conc. for height calc. – mg/L	2500	2500
Maximum Compactability Constant – mg/L	15000	15000

The model was calibrated to match predicted values with the actual reported average values of effluent ammonia, nitrate and nitrite concentration, volatile fraction of the MLSS, solids production in the waste activated sludge (WAS) stream, and digested solids production. The model predictions are in relatively good agreement with the plant data for average annual and maximum month conditions. Model calibration results are presented in Table 4.10 and 4.11.

Table 4.10 BioWin™ Simulation Model Calibration Results – Average 2006 - 2009 Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona			
	Model Output for Average		
Parameter	**Actual**	**BioWin™**	**Commentary**
MLSS (mg/L)	2,491	2,524	
MLVSS (mg/L)	2,005	1,910	
WAS (mg/L)	6,547	5,878	
Effluent TKN (mg/L)	2.1	1.63	
Effluent NH_3-N (mg/L)	1.9	0.39	Actual average NH_3-N and NO_X-N may be higher due to diurnal flows.
Effluent NO_x-N (mg/L)	4.1	3.53	
Process Parameters			
F:M_V (lb BOD/lb MLVSS)	0.11	0.12	
SRT (days) (total/aerobic)	9.8	9.8	
WAS (lbs/d)	4,045	3,682	Average historical WAS values may be confused by returns and influence of Airport WRF solids. Model data matches April 2009 data when Airport sludge was diverted.

Table 4.11 BioWin(TM) Simulation Model Calibration Results – Maximum Month 2006 - 2009 Technical Memorandum No. 3S - Sundog WWTP Existing Conditions City of Prescott, Arizona			
	Model Output Current		
Parameter	**Max Month Summer**	**Max Month Winter**	**Commentary**
MLSS (mg/L)	4,382	4,912	
MLVSS (mg/L)	2,967	3,722	
WAS (mg/L)	10,203	11,438	
Effluent TKN (mg/L)	2.03	1.61	
Effluent NH_3-N (mg/L)	0.38	0.40	The model indicates that the plant could **nitrify** under sustained max month flow conditions **if** the MLSS could be contained in the aeration basin. However at an average SVI of 170 mL/g this is not possible.
Effluent NO_x-N (mg/L)	3.79	3.39	
Process Parameters			
$F:M_V$ (lb BOD/lb MLVSS)	0.14	0.13	
SRT (days) (total/aerobic)	8.5/5.67	9.84/6.56	
WAS (lbs/d)	7,379	9,935	

4.5 Sundog WWTP Capacity Evaluation Criteria

Overall plant capacity is determined by the individual firm capacity of individual unit processes. The evaluation criteria of the individual unit processes are summarized in Table 4.12.

Table 4.12 Wastewater Treatment Process Units Evaluation Criteria
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

	Process Equipment Evaluation Criteria	
	Criteria	**Commentary**
Headworks	- Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows.
Primary Clarifiers	- Influent Flow	Maximum rated capacity was compared to peak daily or peak hourly flows
Tertiary Filters	- Hydraulic peak flows - Secondary effluent turbidity	Maximum rated capacity was compared to peak daily or peak hourly flows
Chlorine Contact Tank	- Hydraulic peak flows	Maximum rated capacity was compared to peak daily or peak hourly flows
Belt Filter Press	- Digester Efficiency	Maximum rated capacity was compared to peak weekly solids production
Oxidation Ditches Final Clarifiers Screw Pumps WAS pumps Sludge Thickening Anaerobic Digesters	- Influent flow - Influent loads - Solids retention - Time (SRT) - Mixed Liquor Suspended Solids (MLSS)	BioWin^{TM} modeling

The secondary process treatment capacity, sludge thickening and anaerobic digester capacity were all evaluated based on their capacity to operate effectively at different design influent flow and loadings. The process modeling approach for the activated sludge process was to allow the secondary clarifier overflow rate and solids loading safety factor to determine the maximum acceptable operating mixed liquor suspended solids (MLSS) concentration in the aeration basins. This resulting maximum MLSS results in a calculated solids retention time (SRT) and F:M (lb. 300/lb. MLVSS) of the secondary system. The SRT, and F:M_V were evaluated together with the effluent characteristics to determine whether the predicted performance of the secondary system would be acceptable to meet the effluent quality criteria.

The main requirement in the selection of a minimum required SRT is that the operating aerobic SRT must be long enough to support stable nitrification throughout the year. BioWin^{TM} requires that a nitrifier maximum specific growth rate (μ_{MAX}) and a nitrifier decay rate be selected. The default value of 0.7/d with an Arrhenius factor of 1.072 for nitrifier growth and a value of 0.17/d with an Arrhenius factor of 1.029 was utilized in the evaluation. The Arrhenius factor adjusts the μ_{MAX} and b_N for wastewater temperature using the formula:

$$\mu_T = (\mu_{MAX}) \times 1.072^{(T-20)} - b_N \times 1.029^{(T-20)}$$

Where:

μ_T = Specific growth rate @ T

μ_{MAX} = Maximum specific growth rate

T = temperature

b_N = decay rate constant

The minimum aerobic SRT during winter for this selected μ_{MAX} is then calculated at $1/\mu_T$ or 3.76 days without any safety factor. Safety factors are required as the minimum SRT does not account for hydraulic effects, and other factors like diurnal flow patterns. The safety factor employed in this evaluation is 250% for a minimum aerobic SRT of approximately 9.4 days. A shorter aerobic SRT compromises the ability of the plant to successfully nitrify, especially under winter conditions.

The clarifier capacity is determined using Solids Flux theory. The Daigger correlation was used for determining the settling velocity and a compression factor for the mixed liquor solids. Ekama also proposed that an 85% safety factor needs to be applied to the solids flux curve. The purpose of maintaining a clarifier flux safety factor of 85% is to prevent solids carryover in the effluent from the secondary clarifiers. The expected clarifier solids flux at the calculated SRT/MLSS, and RAS is then plotted on the solids flux curve. The maximum solids flux occurs at the intersection of the Solids Flux curve adjusted by the 85% Ekama factor.

Effluent characteristics are other important criteria in determining the capacity of the secondary process. The governing criterion for this analysis was the effluent total nitrogen (TN), which is the sum of ammonia (NH3-N), nitrate (NO3-N), nitrite (NO2-N), and organic nitrogen. A maximum total inorganic nitrogen (TIN) concentration of approximately 6 mg/L was selected. TIN includes ammonia, nitrate and nitrite nitrogen. This criterion allows the organic nitrogen concentration to be approximately 2 mg/L before the effluent TN reaches the alert level of 8 mg/L, as identified by the plant's Aquifer Protection Permit. Plant records for 2006-2009 indicated that the average effluent organic nitrogen concentration was approximately 0.91 mg/L.

In addition to the TN criterion, maximum effluent ammonia and nitrite concentrations of approximately 2.0 and 1.0 mg/L, respectively, were used for the evaluation. These concentrations are mainly controlled by the extent of nitrification in the system. The most critical conditions are maximum month loadings during winter conditions, which result in decreased aerobic SRT values that make nitrification during winter months the controlling factor.

4.6 Capacity Determinations

4.6.1 Preliminary Treatment

The influent Parshall flume has a maximum flow measurement capacity of 10 mgd. The mechanical screen and pista grit removal units at the headworks facilities have a rated peak flow capacity of 15 mgd. The bar screen capacity is based on a maximum clear velocity of 4.5 feet per second (fps) at the maximum water level.

As discussed in TM7, the flow equalization is recommended to limit peak hour flows to the tertiary filters at maximum month flows or 2 times average annual flow. For purposes of this TM, maximum hour flow will be considered at a minimum peaking factor of 4.5 or 21.87 mgd.

4.6.2 Primary Treatment

Each primary clarifier has a surface area of 4,350 ft^2, with a SWD of 10ft. Table 4.11 presents the primary clarifier operating conditions:

Table 4.13 Primary Clarifier Evaluation
Technical Memorandum No. 3S - Sundog WWTP Existing Conditions
City of Prescott, Arizona

Flow (mgd)	Process Equipment Evaluation Criteria	
	Surface Overflow Rate (gpd/ft^2) – both in service	Surface Overflow Rate (gpd/ft^2) – one in service
Average (2.58)	297	593
Maximum Month (5.16)	593	1,186
Design Average (6)	690	1,379
Design Peak Hour (15)	1,724	3,448

Typical primary clarifier design SORs are 800 - 1,200 gpd/ft^2 for average flow, and 2,000 - 3,000 gpd/ft^2 for peak flow. The clarifier surface area is within typical design values for current conditions. The firm capacity of the primary treatment process without improvement is estimated to be an average 3.1 mgd, or peak 13.1 mgd.

For modeling purposes, the primary clarifier solids removal efficiency has been estimated at 60%.

4.6.3 Secondary Treatment – Oxidation Ditches and Clarifiers

The capacity of the oxidation ditches and final clarifiers is directly related to the operating MLSS concentration in the basins. The capacity of the basins for BOD_5 and nitrogen load increases with the operating MLSS, but the operating MLSS concentration also determines the capacity of the secondary clarifiers. The capacity of the secondary clarifiers decreases with operating MLSS (assuming constant SVI), because the solids loading rate on the clarifiers increases with increasing MLSS. Therefore, the capacity of an activated sludge system is an optimum combination of aeration basin volume and secondary clarifier surface area. Operating parameter charts for the secondary process are provided in Appendix A.

The average operation of two secondary clarifiers is illustrated on Figure 4.5. The dark brown line is the Ekama safety factor that is applied to the solids flux based on a **175 mL/g SVI**. The typical flow condition of 2.58 mgd is shown with the open circle and the peak flow condition is shown with the filled circle. Both of these conditions are easily under the solids flux curve indicating that the existing WWTP has adequate clarifier capacity at present flows and average loads. However when one clarifier is removed from service as shown in Figure 4.6, the plant has adequate capacity for average flows but not for peak flow conditions.

The methodology used in evaluating the Sundog WWTP was to calculate a minimum clarifier safety factor of 2.0. The methodology employed is as follows:

- Calculate the initial settling velocity using the Vesilind equation ($V_x = V_o \times e^{(-nX)}$). The initial settling velocity (ISV = V_X) is calculated at the specific aeration basin MLSS that is being considered.
- Measure or utilize literature references for the two parameters V_o and n, when site-specific values are not available. (For this study, the Daigger correlation has been used to estimate settling parameters).
- The Clarifier Safety Factor (CSF) is then calculated by dividing the initial settling velocity by average day flow Surface Overflow Rate. A value greater than 2 is desired for a minimum safety factor. This typically provides sufficient capacity to accommodate peak flows.

The average clarifier safety factor is 5.1/2.55 for 2/1 clarifiers respectively. The CSF approach may not be conservative enough for the peak wet weather conditions. Problems with inflow and infiltration (IOI) in the Prescott sewage collection system should be addressed to reduce these extraneous flows. IOI considerations are addressed further in Technical Memorandum No. 4 – Influent and Effluent Management."

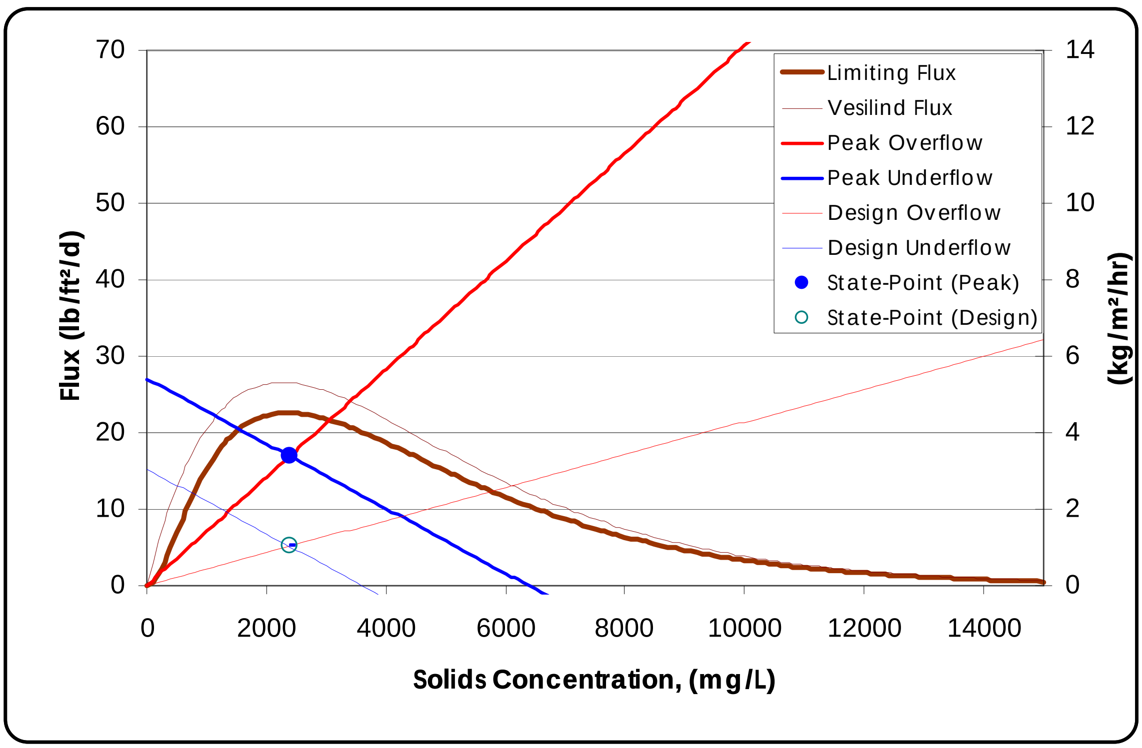


Figure 4.5 Sundog WWTP Clarifier Analysis at Average 2006 to 2009 – 2 in Service

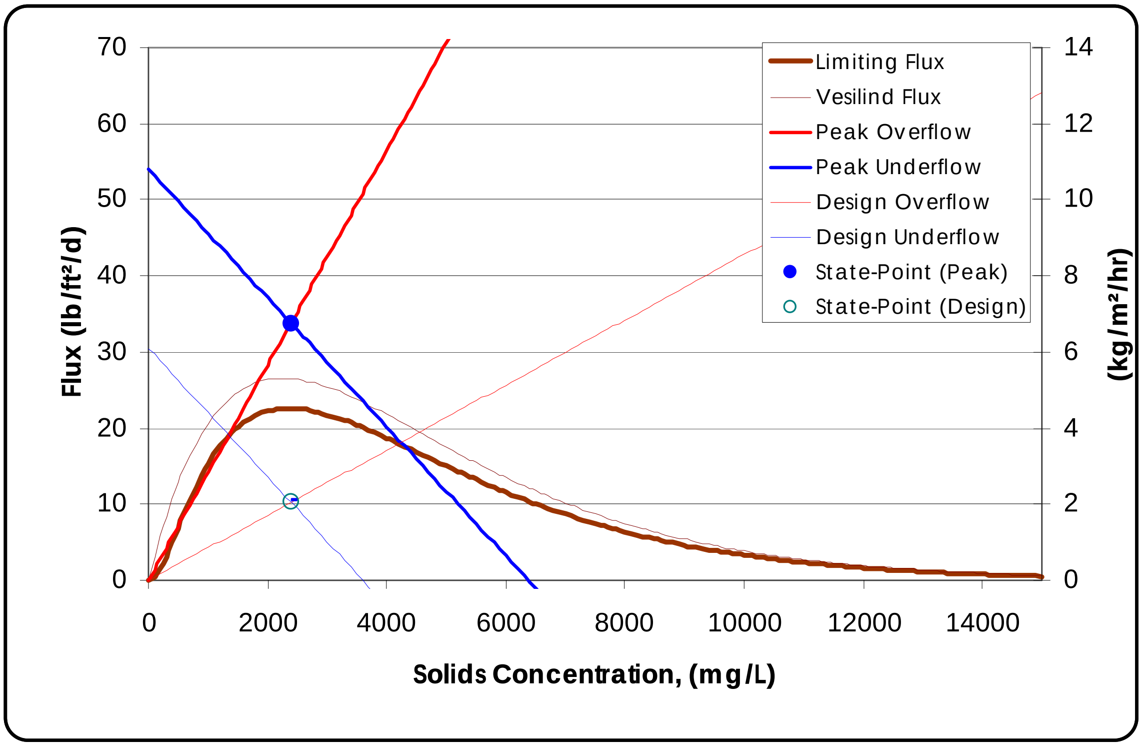


Figure 4.6 Sundog WWTP Clarifier Analysis at Average 2006 to 2009 – 1 in Service

The model was then utilized to simulate maximum month concentration conditions at average flow, and average month concentration conditions at maximum month flow.

The average operation of two secondary clarifiers at [Max Month] and Average Flow is illustrated below in Figure 4.7. The typical flow condition of 2.58 mgd is shown with the open circle and the peak flow condition is shown with the filled circle. Both of these conditions are under the solids flux curve indicating that Sundog WWTP has adequate clarifier capacity at average flow and maximum month concentration. However when one clarifier is removed from service as shown in Figure 4.8, the plant will fail under peak flow conditions.

The average operation of two secondary clarifiers at [Avg concentration] and Max Month flow is illustrated below in Figure 4.9. Both max month flow conditions are outside the solids flux curve indicating that Sundog WWTP clarifiers will fail under this loading condition.

The [Max month], average flow clarifier safety factor is 2.0/1.0 for 2/1 clarifiers respectively. The CSF approach confirms that the plant will fail under one clarifier operation. The [Avg month], max flow clarifier safety factor is 1.1/0.6 for 2/1 clarifiers respectively. The CSF approach confirms that the plant will fail under this loading condition.

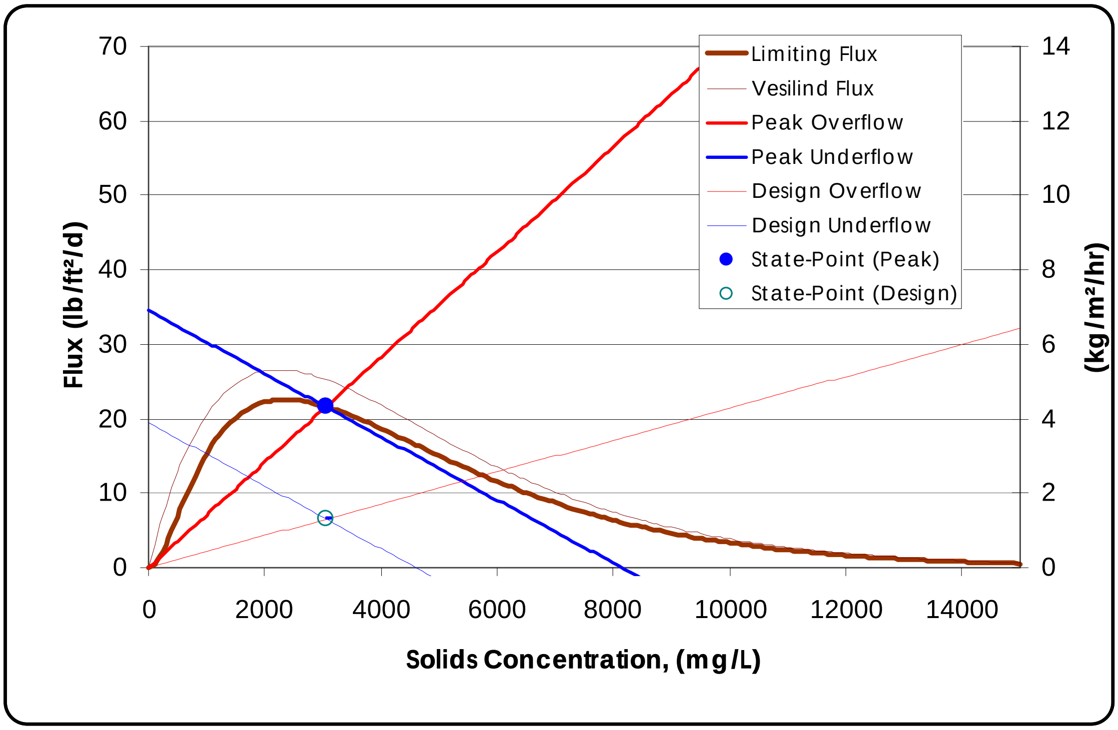


Figure 4.7 Sundog WWTP Clarifier Analysis at [Max Month] and Average Flow, 2006 to 2009 - 2 in Service

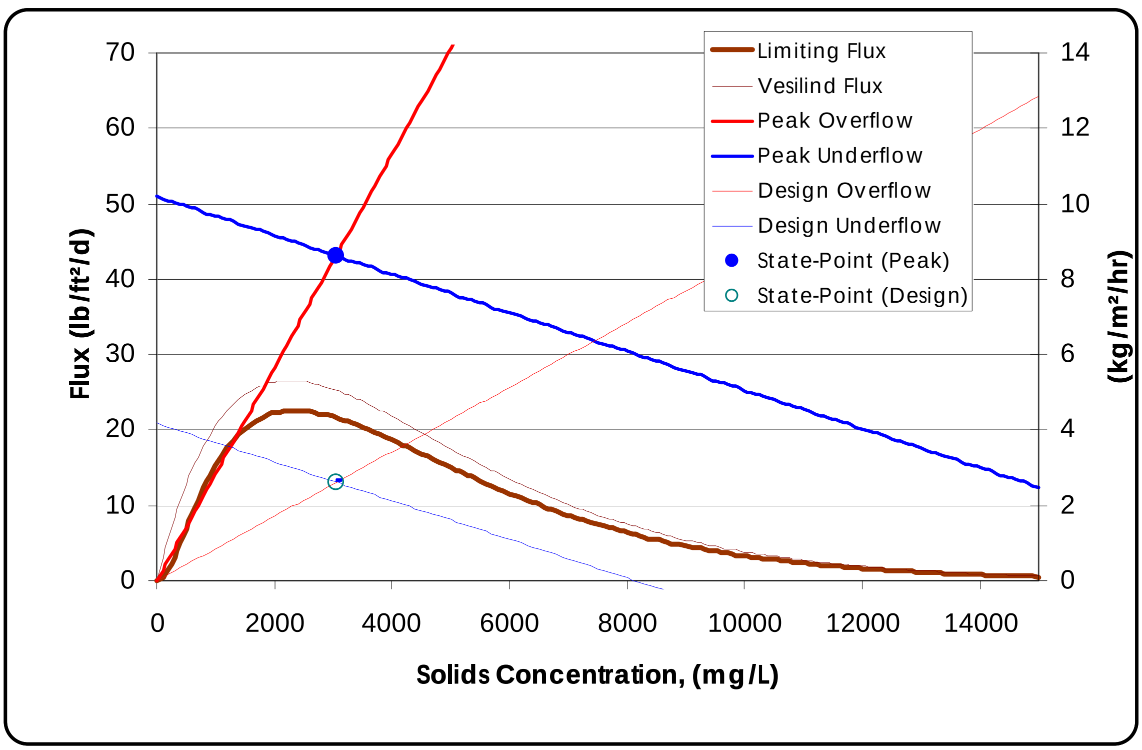


Figure 4.8 Sundog WWTP Clarifier Analysis at [Max Month] and Average Flow, 2006 to 2009 - 1 in Service

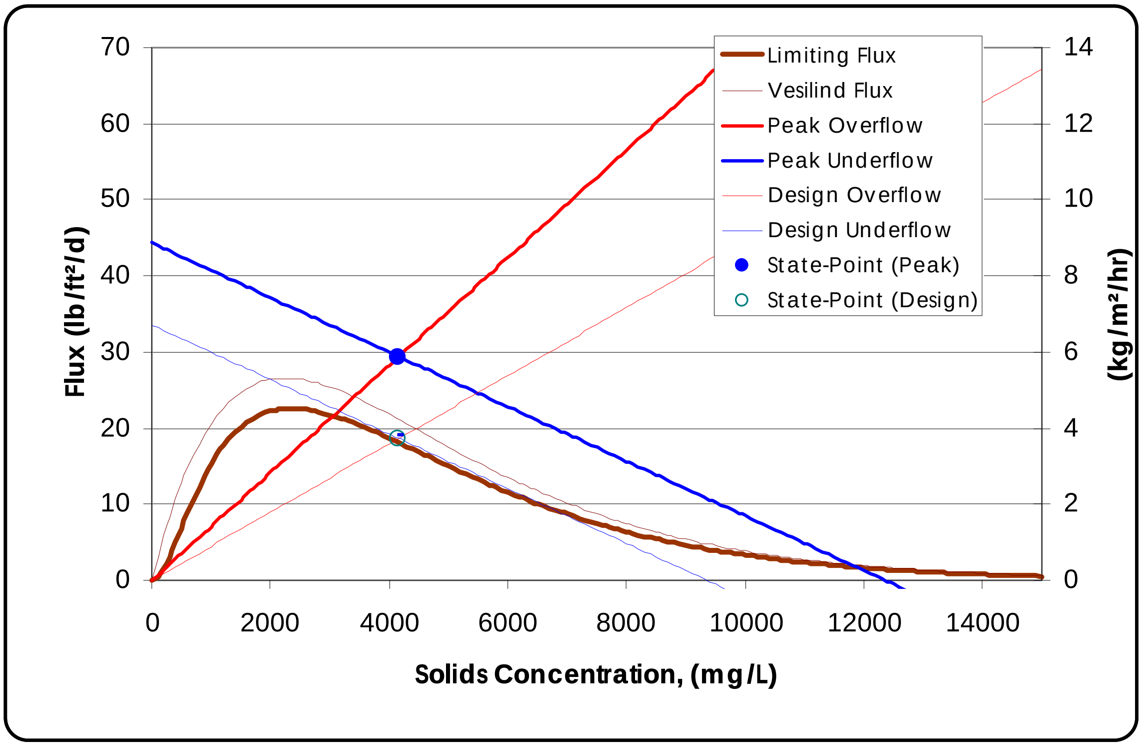


Figure 4.9 Sundog WWTP Clarifier Analysis at [Avg Month] and Max Month Flow, 2006 to 2009 - 2 in Service

4.6.4 Secondary Treatment – Aeration Equipment and RAS Rate

Aeration

The 1990 improvement project design average Standard Oxygen Transfer Rate (SOR) was 1,550 lbs O_2/hr. The model indicates a SOR of 1,421 lbs O_2/hr, and a demand for air during max month flow and average concentrations at 3,603 scfm. Based on these values, the aeration system is adequate for current maximum month flows and average concentrations, but additional supplemental aeration would be required for flows and concentrations beyond current conditions.

Screw Pumps

The current plant has a RAS firm capacity of 2,100 gpm each, with two pumps in operation and one pump in standby. Based on process model calculations, the RAS is sufficient to maintain the required RAS flows up to the design plant flow of 6.0 mgd. The RAS capacity of 6 mgd translates to a RAS ratio of 40 percent at the peak day flow capacity under current conditions.

Denitrification

As part of the capacity analysis, a field investigation was conducted to assess periodic operating challenges to achieve complete denitrification.

The investigation consisted of DO and temperature profiling in addition to physical observations. In general, the major findings of the field investigation included identification of a flow split imbalance between ditch 1 and 2, the need for improved DO control and the need for testing the process response to polyaluminum chloride addition. Detailed analysis and findings are described in Appendix C.

4.6.5 Tertiary Treatment

Tertiary treatment is addressed in TM7.

UV Disinfection

Disinfection of the effluent in 1988 was through chlorine disinfection. However, UV disinfection equipment was recently installed in 2002 to disinfect pathogens. One of the chlorine contact tank channels was modified to accept UV disinfection banks. The disinfection system is intended to produce a disinfected effluent that could be “recharged, stored and recovered from the groundwater.” The UV system is designed to ensure compliance with the disinfection requirements of Class B+ reclaimed water. Class B+ reclaimed water must meet the following criteria[2] after disinfection treatment and before discharge to a reclaimed water distribution system:

a. The concentration of fecal coliform organisms in four of the last seven daily reclaimed water samples is less than 200 / 100 ml.

b. The single sample maximum concentration of fecal coliform organisms in a reclaimed water sample is less than 800 / 100 ml.

Figure 4.10 indicates that the Sundog WWTP typically is in compliance with Class B$^+$ reclaimed water criteria.

[2] Arizona Administrative Code. R18-11-305. Class B+ Reclaimed Water

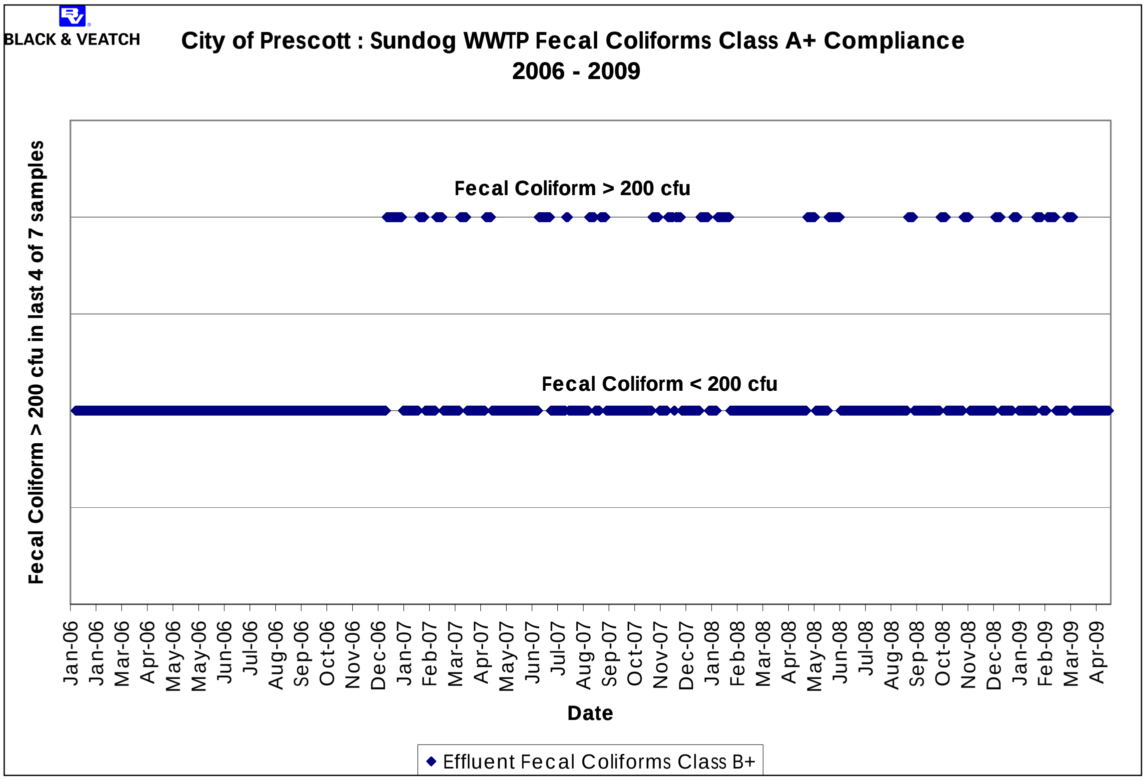


Figure 4.10 Sundog WWTP Compliance with Class B+ Reclaimed Water Criteria - 2006 to 2009

The reasons for non compliant disinfection could be due to turbidity, UV transmissivity of the effluent, fouled lamps or reduced lamp efficiency. However, some of the excursions in January 2008 are attributable to higher effluent turbidity. The plant also injects chlorine into the effluent upstream of the UV disinfection system to assist in algae control. This chlorine injection is helpful in keeping UV lamps clean. However, the average chlorine residual and disinfection contact time is probably too low to assist in controlling excursion fecal coliforms as Figure 4.11 indicates. In some instances this could be as a result of high ammonia in the effluent. Residual ammonia in the effluent results in the formation of chloramines rather than free chlorine. Chloramines are not as effective a disinfectant as free chlorine.

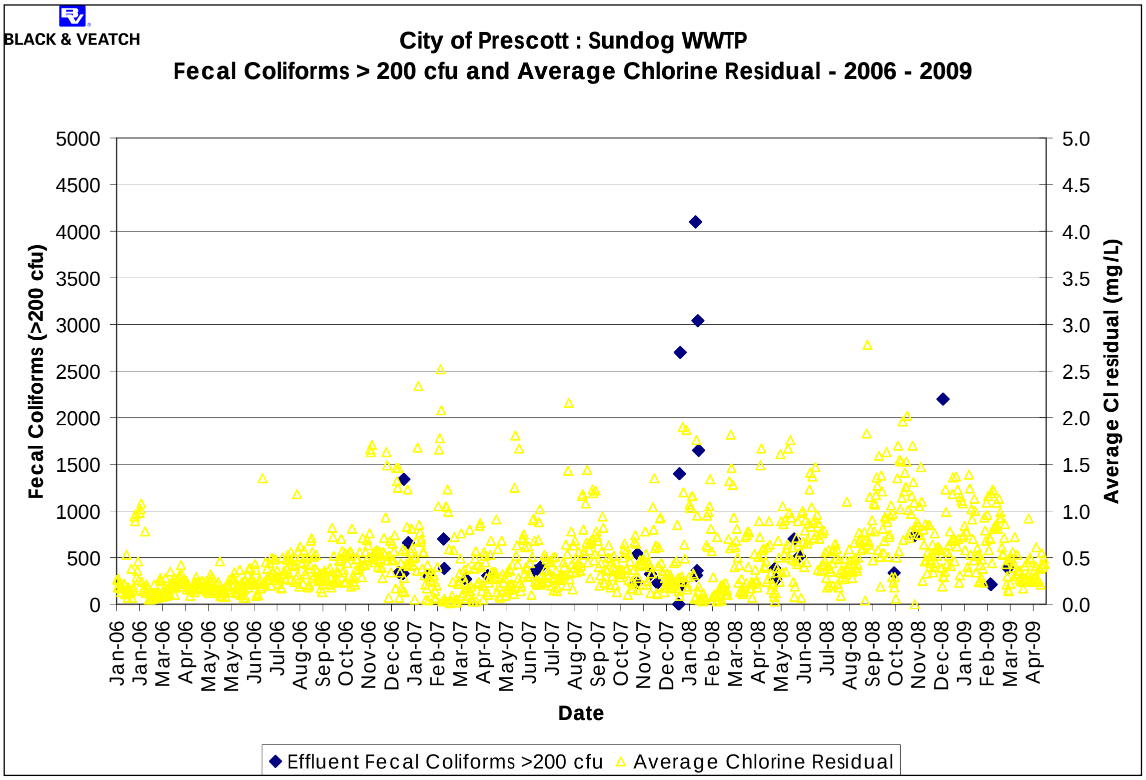


Figure 4.11 Sundog WWTP Fecal Coliforms >200 cfu/100 mL and Average Chlorine Residual - 2006 to 2009

The UV and chlorine dosing system may be adequate for current flows and current effluent ammonia levels with Class B^+ reclaimed water criteria. However, the UV system must be expanded for Class A^+ reclaimed water criteria.

4.6.6 Biosolids Thickening, Stabilization and Dewatering

Biosolids Thickening

Primary sludge is thickened in the primary clarifiers and waste activated sludge is thickened with gravity belt thickeners. The gravity belt thickeners were sized as 2 units (1 out of service currently), 1 meter belt width, for an average WAS load of 3,780 ppd and a maximum WAS load of 4,540 ppd. The simulation model estimates an average WAS load of 4,250 lbs/d and a 92% load of 7,255 lbs/d. The single gravity belt thickener is operating at the maximum design condition. Additional thickening capacity is required.

Anaerobic Digestion

The digester feed and wasted VS loads are provided in Figure 4.12. The Airport WRF activated sludge was stabilized in the Sundog WWTP digesters until April 17, 2009, when the Airport WRF centrifuge came online.

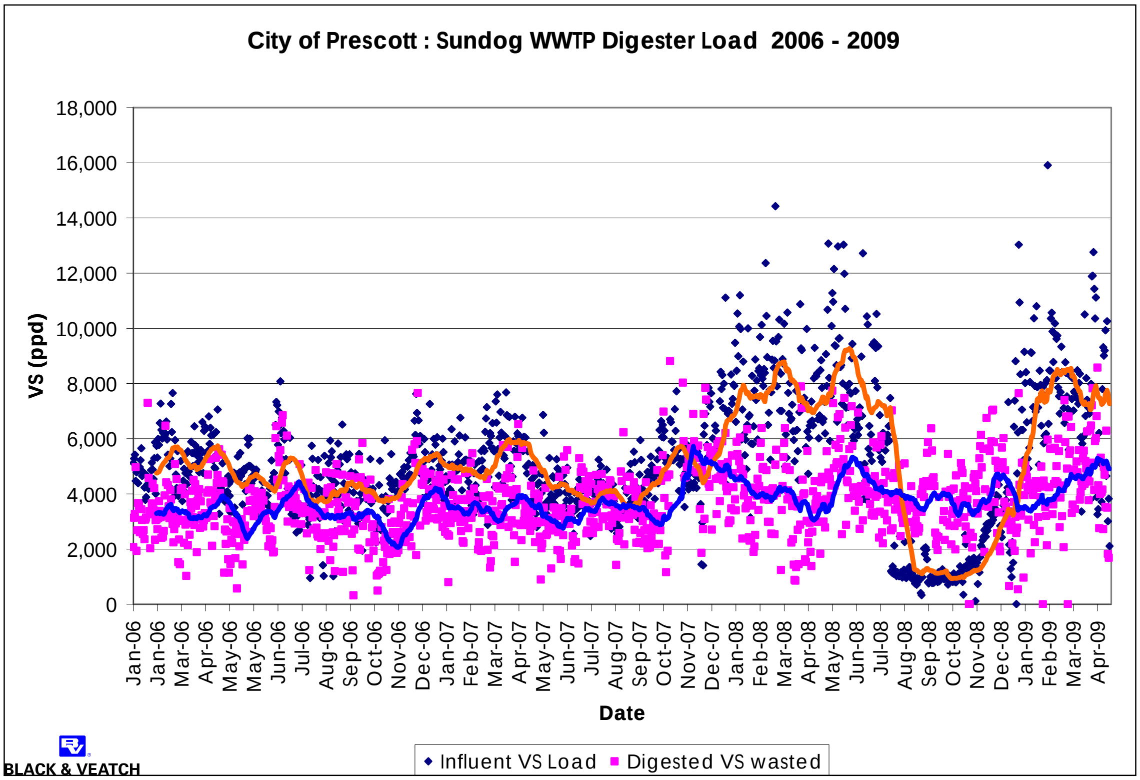


Figure 4.12 Sundog WWTP Anaerobic Digester VS Influent and Wasted – 2006 to 2009

The 2 anaerobic digesters were sized for a volatile suspended solids load of 2,590 lbs/day. This is a VS load of 0.026 lbs VS/d/ft^3 with both tanks in service and 0.052 lbs/d/ft^3 with one tank in service (during digester cleaning). Conservative design practice suggests a VS loading rate of 0.04 to 0.1 lbs VS/d/ft^3. The average influent VS load based on the simulation model was approximately 6,653 lbs/d. The average influent VS load measured during 2006-2009 was 7,612 lbs/d. The maximum VS load based on the simulation model was estimated to be 12,221 lbs/d and the measured 92%ile load was 11,456 lbs VS/d/ft^3. The reason for the measured average higher loading rates is the additional load from Airport WRF. The modeled VS loading rates are 0.068 and 0.125 lbs VS/d/ft^3, while measured VS loading rates are 0.078 and 0.117 lbs VS/d/ft^3 respectively for **both** digesters in service. The average VS reduction was 45% but this is not a stable or reliable operating condition and has been declining as shown in Figure 4.13.

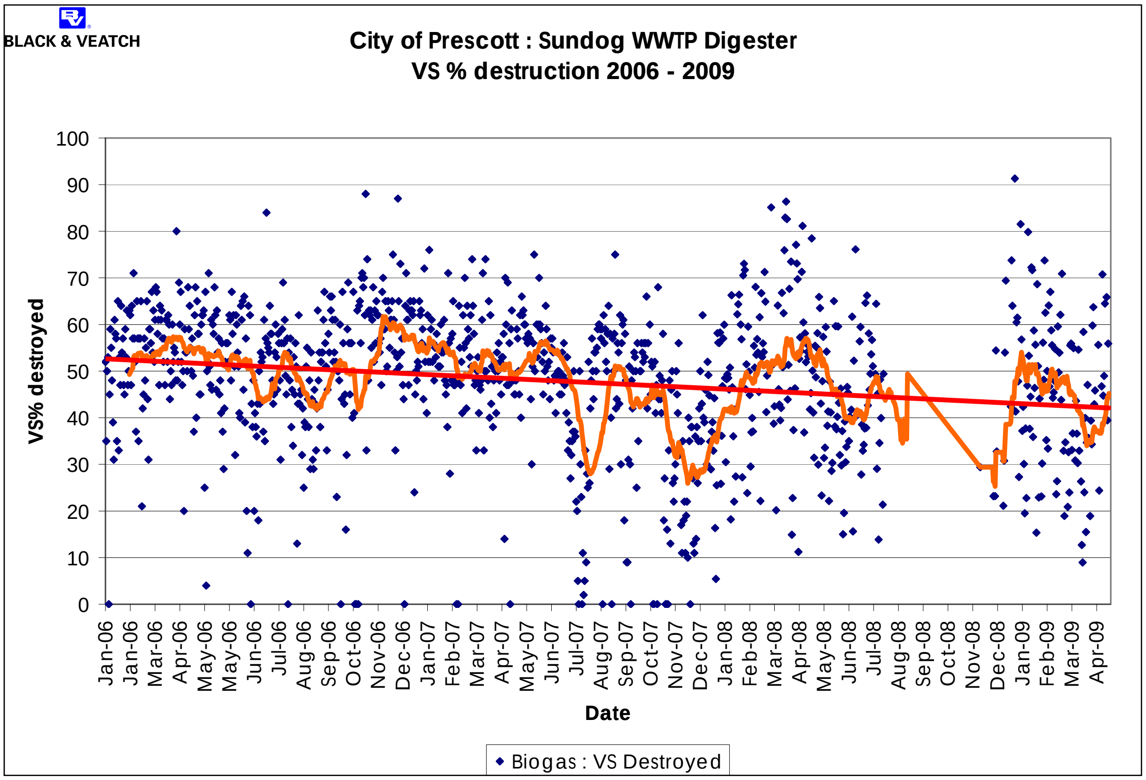


Figure 4.13 Sundog WWTP Anaerobic Digester VS% Destruction - 2006 to 2009

The biogas generation rates per lb of VS destroyed is presented in Figure 4.14. This data includes Airport WRF biosolids. The biogas generation rates have been declining as the linear trend line suggests. This implies that digestion is no longer as effective. There could be multiple reasons for this including overloading, reduced mixing efficiency, less efficient primary clarifier performance, and buildup of grit in the digesters reducing effective volume (although grit accumulation is unlikely as very little was found when cleaning the secondary digester in 2007). Presently the WWTP has insufficient capacity to remove a digester from service to inspect these tanks.

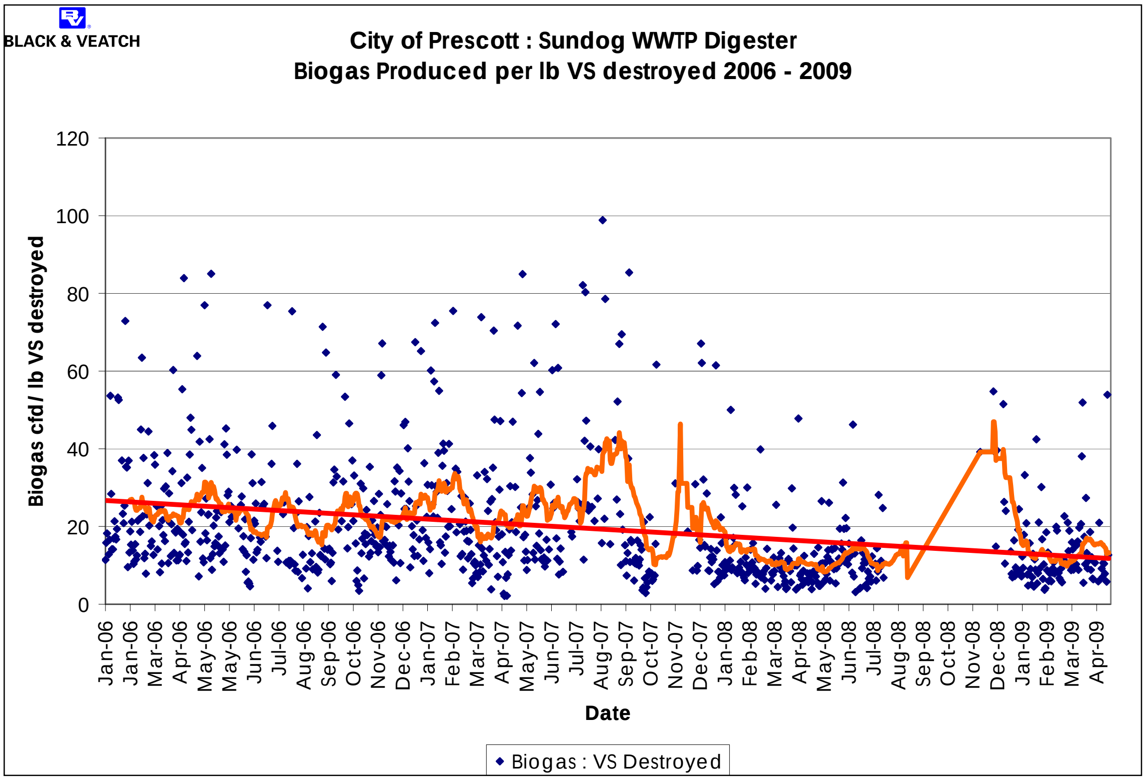


Figure 4.14 Sundog WWTP Anaerobic Digester Biogas Produced per lb VS Destroyed - 2006 to 2009

The anaerobic digesters are inadequate for processing current flows and loads with Airport WRF solids. However, with the Airport WRF operating a new centrifuge this should not be an issue except under extreme equipment failures. The digester capacity is sufficient for Sundog WWTP 2009 flows and loads, but additional capacity is required for maintenance of reliable operation at current loads.

Sludge Dewatering

A single 2m wide belt filter press provides dewatering of digested sludge prior to disposal. The requirements described in the Sundog WWTP design Improvement memorandum was for a 7 hrs/day, 7 days a week operation. The modeled average wasted biosolids loads are 5,146 lbs/d. The wasted biosolids load from the digesters is provided in Figure 4.15. The measured average TS wasted in 2006-2009 was 5,240 lbs/day (including stabilized Airport WRF sludge). The 92% TS wasted was 7,800 lbs/d. Belt filter presses are typically sized by solids loading rate. A reasonable solid dewatering rate is 750 lbs/m of belt width/hr of operation. Therefore the average digested biosolids production will require 5,146/750 or 7 hours/day operation. The 92% ile load currently requires 7,800/750 or 10.4 hours of maximum operation per day. Typical operation occurs 5-6 hours each day.

The single belt filter press was operating at the design condition (49 hours/week) under average loads and above the design condition for higher loads. However, diverting Airport WRF has reduced the solids dewatering load. In addition, a single belt filter press provides no redundancy particularly coupled with anaerobic digesters that are also operating at capacity. Additional solids dewatering capacity is required for reliable operation at current loads.

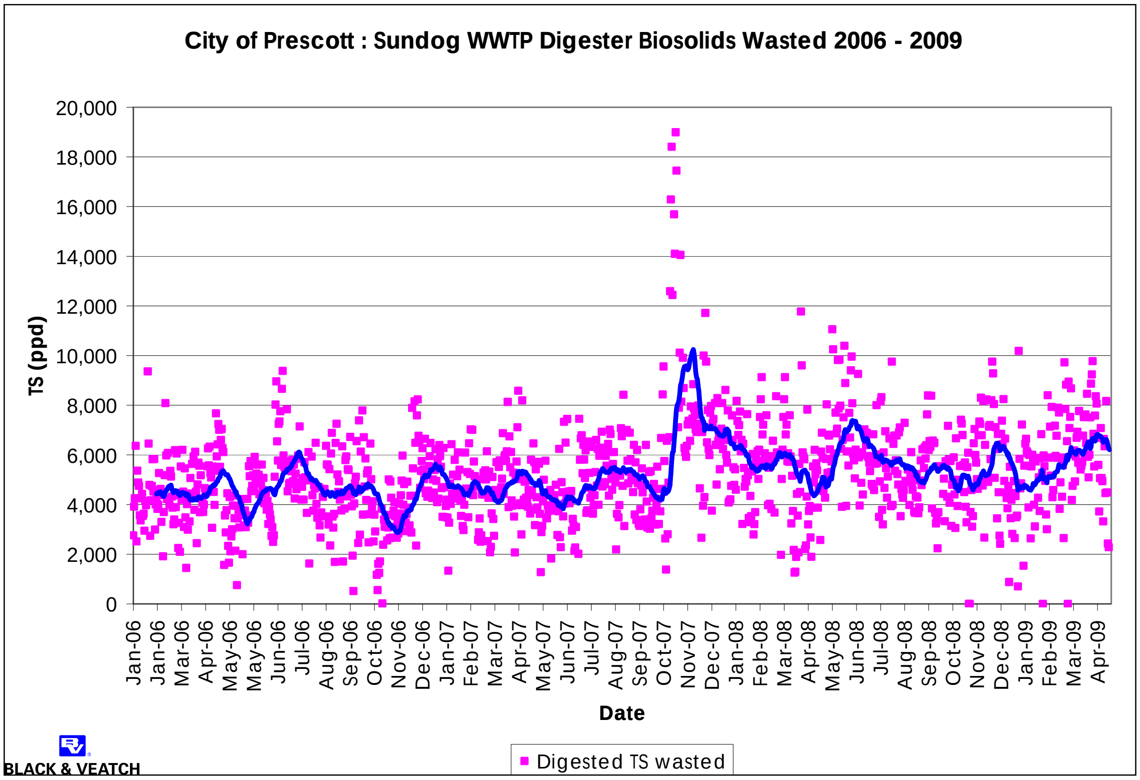


Figure 4.15 Sundog WWTP Anaerobic Digester TS Wasted - 2006 to 2009

4.7 Capacity Analysis Summary

Figure 4.16 summarizes the capacity analysis for the existing facilities at the Sundog WWTP. The overall plant hydraulic capacity remains at the original design capacity of 6.0 mgd and unit process that are hydraulically sized (bar screen, grit removal, primary clarifiers) are still in alignment with the original design parameters. However, the overall treatment capacity of the existing plant has been reduced to approximately 3.0 mgd compared with the original design capacity of 6.0 mgd. The reason for this reduction in capacity is the fact that influent concentrations have more than doubled for influent BOD_5 and TSS and this has a corresponding impact on the biological treatment system (aeration basins and secondary clarifiers) and solids related processes (sludge thickening, sludge dewatering, anaerobic digesters). These unit processes limit the overall treatment capacity to approximately 3.0 mgd as shown in Figure 4.16. The following comments are also noted regarding the unit process capacities:

- Figure 4.16 gives the average day capacity for biological treatment, filtration, and UV disinfection. In order to maintain these rated capacities, the Sundog WWTP will require flow equalization facilities to handle peak wet weather events.

- There is only a single gravity belt thickener for thickening WAS – a redundant unit is recommended to maintain reliable capacity. The existing unit is operated continuously to maintain capacity and optimize performance.

- The entire digested sludge dewatering facility, while "rated" at 3.0 mgd, is near the end of its useful life and needs to be replaced. The existing unit must operate 10 hours per day, 7 days per week during maximum month conditions to maintain capacity.

- The filtration capacity shown is approximate since the existing filters have experienced an underdrain failure and need to be replaced in the near future (see TM #7 – Tertiary Filtration Evaluation).

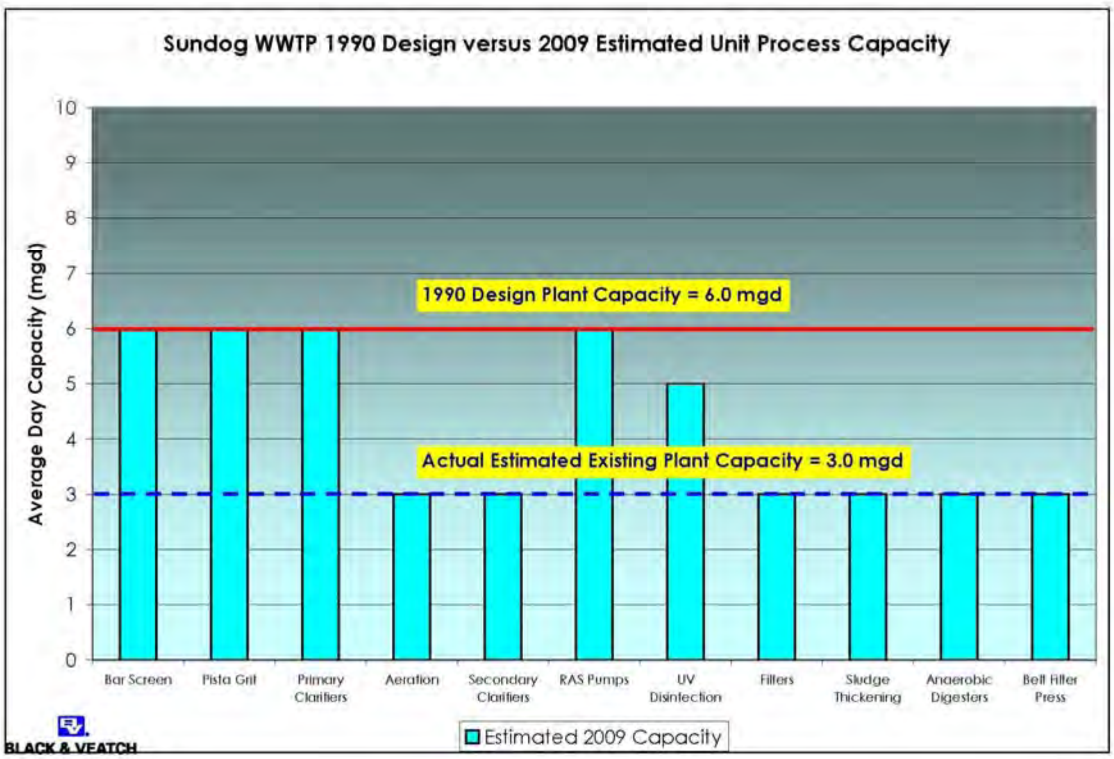


Figure 4.16 Sundog WWTP 1990 Design Versus 2009 Estimated Unit Process Capacity

5.0 PLANT ISSUES, NEEDS AND OPERATIONAL PREFERENCES

5.1 Headworks

The existing Headworks consists of a parshall flume, mechanical bar screen, manual bypass screen and a vortex grit removal basin. The existing 24 inch plant influent discharges to the Headworks facility. A new Sundog Trunk Main is scheduled to begin a 3 year phased design in 2010 design and 2011 start of a 3 year construction phasing. The alignment of the new trunk main has yet to be determined and will determine the location of the new Headworks facility.

The parshall flume is utilized for influent flow measurement utilizing an ultrasonic level detector. Prior to 1990 the ultrasonic was not programmed to read flows higher than 5.0 mgd. The ultrasonic has since been reprogrammed to measure flows up to 10.0 mgd. The plant experiences high wet weather peak flows due to I/I issues, however the extent of the peak flows is unknown due to limitations within the influent flow measurement system. A larger parshall flume is required to accurately measure the actual peak wet weather flows.

A single mechanical bar screen provides influent screening. The 3/4-inch bar spacing allows a significant amount of debris to pass through the screen and into the downstream processes. Raw screenings are discharged to a wheelbarrow for removal by plant staff. The unwashed and uncompacted screenings stored in the wheelbarrow create an odor and vector issue. The plant staff would like to have a second mechanical influent screen to provide redundancy. A washer/compactor is recommended for installation during the next upgrade to clean the raw screenings and reduce odor and vector issues. A washer/compactor will also reduce the manpower required for screenings operations.

A single vortex grit removal basin is located downstream of the influent screens for removal of large inorganic materials such as rocks and cinders. The single basin was originally sized to handle the peak wet weather flows of 15 mgd; however the Smith Loveless Model 20 Pista Grit unit installed is capable of peak flows up to 20 mgd. An approach velocity greater than 2 feet per second is required for proper operation of the system, which equates to approximately 3.5 mgd. Influent flows frequently fall below this number and create operational issues. The plant staff, along with the manufacturer, has installed a baffle plate on the inlet to reduce the inlet channel width and increase the influent flow velocity. Two half size grit chambers would provide better process control and allow isolation of a single unit during sustained periods of low flow. A single new grit concentrator can be installed to serve both of the grit chambers. The large amount of grit accumulation in the oxidation ditches confirm the lack of performance.

The recommendations for the Headworks are as follows:

- New Headworks facility to be coordinated with new Sundog Trunk Main.
- Parshall flume sized for peak wet weather events equipped with ultrasonic level detector programmed for entire range of influent flows.
- Redundant influent screens.
- Screening washer/compactor to decrease operations and reduce odor and vector issues.
- Multiple smaller vortex grit basins to handle the wide range of influent flows.
- Integrated septage receiving station, refer to Section 5.9.

5.2 Primary Clarifiers

The existing secondary clarifiers were retrofit during the 1990 plant expansion to serve as the primary clarifiers. A splitter box divides the flow and directs it to the individual clarifiers. The primary sludge pumps are on timer control. Scum collected from the surface of the clarifiers is pumped to a sludge drying bed for disposal creating an odor and vector issue.

The recommendations for the primary clarifiers are as follows:

- Install sludge blanket level detectors for process control and procure hand held devices.
- Filter the scum and meter to the anaerobic digesters in lieu of disposal to the drying bed.

5.3 Settled Sewage Pump Station

The Settled Sewage Pump station consists of three arcamedian screw pumps to deliver flow to the oxidation ditches. The pump station receivers, primary effluent, RAS, filter backwash and filtrate flows. Only two of the pumps can be on standby power. Plant staff stated that power failures longer than 10 minutes result in overflowing of the filtrate manholes due to backflow in the line. A check valve is recommended to resolve this issue.

5.4 Oxidation Ditches and Aeration Blowers

The oxidation ditches receive flow from the Settled Sewage Pump Station and are a racetrack configuration. The aeration blowers provide coarse bubble diffused aeration during peak loadings. The original aeration system was designed for DO control; however the DO probes have been removed and aeration blowers are operated manually. The brush rotors in the oxidation ditches are on timer control based on operator experience. The rotors are either on or off without VFD control.

DO control of the aeration system, blowers and rotors, would assist process control within the oxidation ditches. Manual operation of the aeration system has either resulted in increased dissolved oxygen concentrations which inhibit denitrification or low dissolved oxygen levels which leads to lack of nitrification. The overall result is a cyclical process that is either providing too much aeration or not enough aeration.

The racetrack configuration has a long anoxic section without sufficient mixing which has resulted in solids settling within the oxidation ditches. This is further exacerbated by the inefficiency of the grit removal and primary clarification processes. The ditches have recently been drained and large deposits of grit removed. Increased operation of the rotors to provide sufficient mixing results in increased levels of nitrates in the effluent, while decreased operation results in odors and setting of sludge within the basins. Optimization of the rotor operation or additional mechanical mixing is recommended to resolve this issue.

The cyclical operation of the aeration system has resulted in filamentous growth within the oxidation ditches producing foam and mixed liquor with high SVI. A recent microscopic examination stated that 1) high levels of grease and oil, 2) longer sludge age and 3) septicity or low oxygen conditions are the cause of the foam. Item 1 is discussed in Section 5.10 Grease Receiving. Item 2 is discussed in Section 4 dealing with the process operation of the oxidation ditches to treat the influent flow characteristics. Item 3 is a result of lack of DO control within the oxidation ditches and can be resolved by providing automated control of the aeration system. Chlorination of the RAS along with the addition of a chlorine spray system in the oxidation ditches would provide improved process control.

The recommendations for the oxidation ditches and aeration blowers are as follows:

- Automated DO control for the aeration system to provide better process control and reduce filamentous growth.
- Mechanical mixing to improve mixing within the anoxic zones.
- Chlorine spray system to control surface foam in the oxidation ditches.
- Chlorination of the RAS line.
- Install launder or V-notch weirs in flow splitter.
- Install VFDs on all brush rotors.
- Install DO probes, 4 per ditch.
- Install PLC for DO control.
- Install submersible mixers.

5.5 Secondary Clarifiers

The two secondary clarifiers receive flow from the oxidation ditches. Settled solids are either returned to the Settled Sewage Pump Station as RAS or wasted to the single operating gravity thickener. Scum collected from the surface of the clarifiers is pumped to Settled Sewage Pump Station. RAS flows by gravity to the Settled Sewage Pump Station and is controlled by in-line flow meter and control valves. Two waste sludge pumps deliver WAS to the gravity belt thickener in the Digester Building.

Algae growth on the weirs and launders is an operational issue. The algae is currently removed by manual cleaning which takes one of the plant staff between 4 to 6 hours per week. The installation of launder covers would prevent the growth of algae on the weirs and launders and allow plant staff to concentrate on process control issues rather than nuisance control.

The recommendation for the secondary clarifiers are as follows:

- Install sludge blanket level detector for process control.
- Provide launder covers to reduce algae growth.

5.6 Tertiary Filtration

The existing traveling bridge filters have experienced failure of the underdrains. The evaluation of the existing filters along with recommendations is located in TM7 Tertiary Filter Evaluation.

5.7 Disinfection

The original chlorine contact basins were retrofit with UV disinfection in 2002. The current UV disinfection system is a Trojan 3000 medium pressure unit. The existing system was installed without a wiper system to clean the lamps. Over time contaminants bake onto the lamps reducing efficiency. The plant staff currently injects a maintenance dose of 30 ppd of chlorine upstream of the filters. The basin is uncovered resulting in algae growth within the basin and on the lamps and allows dust into the effluent reducing transmissivity.

The recommendations for the UV disinfection system are as follows:

- Automated flow pacing and transmissivity control.
- Install wiper system to maintain efficiency and improve lamp life.
- Adjust effluent gate control to reduce cycling
- Cover basins to reduce algae growth and prevent dust intrusion.

5.8 Solids Processing

Waste activated Sludge (WAS) is pumped from the secondary clarifiers to the gravity belt thickener in the Digester Building. Thickened solids are collected in a wet well and pumped into the primary anaerobic digester. Primary sludge from the primary clarifiers are pumped directly to the wet well. Two anaerobic digesters are operated in series to stabilize the sludge. Digested solids are pumped to a belt filter press for dewatering and sent out for land application.

Two GBTs were originally installed, however one unit has been cannibalized for parts to maintain a single unit in operation. The single GBT is operated 24 hours a day to thicken WAS to approximately 5 percent solids. The second unit can be rebuilt with new parts and placed back into operation to improve process control and provide redundancy.

Plant staff report very good mixing in the digesters with the draft tubes. The plant currently operates at approximately 14 days HRT in the digesters. The digested sludge meets Class B based on VSR of 50 to 55 percent and pathogen measurements; however they do not meet the required TxSRT for Class B. Solids from the Airport WRF were hauled to the Sundog WWTP for processing until April 2009. The digesters were unable to meet Class B requirements for the combined solids loading and hauling operations ceased.

Digested solids are pumped from the digesters to the belt filter press (BFP) located in an adjacent building. There is no significant storage for the digested sludge. Digested sludge is currently batch wasted to the BFP, which is operated 5 to 6 hours per day 7 days a week. City staff has expressed the need for digested sludge storage and additional dewatering equipment to provide redundancy and reduce dewatering operations to 5 days a week with the new Airport WRF centrifuge.

The recommendations for the solids processing are as follows:

- Rebuild the second GBT to provide redundancy.
- Additional digester volume to meet the required 15 day HRT for Class B.
- Digested sludge storage for 5 days per week sludge dewatering operations.
- New dewatering equipment and facility.

5.9 Septage Receiving

The existing septage receiving station was designed to accept septage and slowly pump into the influent. The configuration has been modified and a pipe added to discharge directly into the influent sewer by gravity. This results in slug loading of the biological treatment processes creating process upsets. Ammonia concentrations of up to 180 mg/L have been seen in the blended plant influent.

A new septage receiving station is recommended to be integral to the new Headworks to provide flow and loading control. Septage discharged should be held for testing prior to discharge to the influent to ensure toxic loads are not released into the plant. The septage should then be screened and metered into the influent over a period of time to reduce shock loadings.

5.10 Grease Receiving

The plant currently accepts little grease over the course of the year and is transported via the collection system. All grease is collected in a container and hauled offsite for disposal. The City is currently adopting a FOG Prevention Plan and grease hauling is expected to significantly increase over the coming years. A separate grease receiving station is recommended to accept the grease and discharge to the anaerobic digesters. The reduction of grease in the influent due the FOG Prevention Plan will help reduce the growth of filamentous organisms identified as the cause of surface foaming at the oxidation ditches. Grease feed to anaerobic digesters significantly increases the production of digester gas. The plant currently produces between 37 to 40 kcf of digester gas per day and utilizes approximately 10 to 12 kcf to fire the boilers providing digester heating. The additional digester gas production may provide an opportunity for a new green energy source.

5.11 Flow Equalization

The plant experiences a significant amount of inflow and infiltration during the wet weather months as shown in Figures 4-1 and 4-2. Peak flows have exceeded 9 mgd for the current flow condition, however the true peak flow is unknown due to limitations with the influent flow meter. Peak flows to plant are projected to exceed 21 mgd for the future hydraulic design flow of 5.3 mgd. Flow equalization and I/I control will be required to reduce peak flows to the plant. I/I is addressed in TM No. 4 – Influent and Effluent Management. Flow equalization is recommended onsite to reduce peak flow events for all process downstream of the primary clarifiers. This strategy protects the operation of the biological processes downstream of the primary clarifiers and decreases the amount of infrastructure required for the secondary and tertiary treatment processes.

5.12 SCADA

The plant does not currently have any type of monitoring or control system available due to the SCADA system age and lack of control capability. At the minimum, monitoring of key processes and alarms notifications are desirable in the short-term. Monitoring and alarms would improve the reliability of the system, providing operators the ability to identify major upsets during unattended operation periods. In the long-term, instrumentation and control elements could be incorporated in a plant control system for automation of the major processes, such as secondary process equipment. Automation of major processes will optimize energy consumption, and provide a more reliable operation of the treatment process.

5.13 Electrical

A detailed electrical evaluation is recommended to address the stand-by power requirements of the plant. It is currently planned to replace the existing 300 kW stand-by generator with a 1 MW unit.

5.14 Miscellaneous

Several miscellaneous issues were discussed which are listed below.

- The existing effluent line to the recharge basins is at capacity. A new effluent line will be required for buildout flows.
- The ¾-inch hose bib connections throughout the plant are undersized for washdown operations. Plant supervisory staff expressed interest in providing larger fire hydrant connections for washdown operations.
- The existing non-potable water system requires upgrades to accommodate current and future conditions.

APPENDIX A

PROCESS MODEL RESULTS

BioWin user and configuration data

Project details

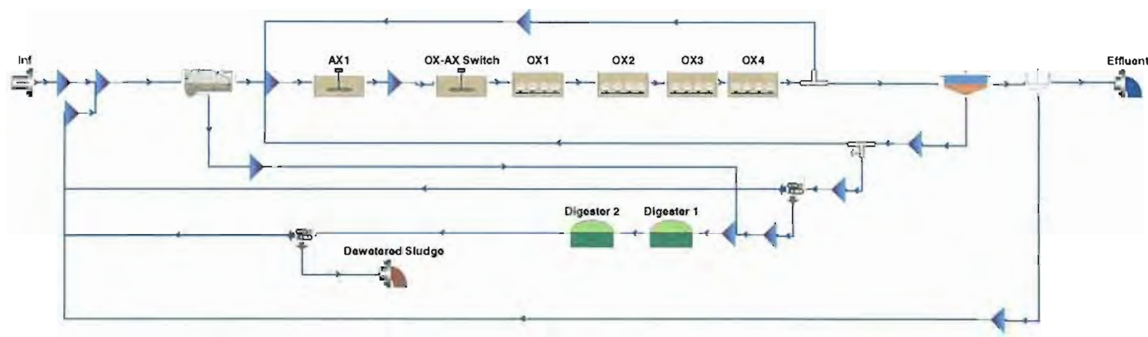
Project name: Phase 1 Average Load and Flow **Project ref.: BW3**
Plant name: Sundog WWTP **User name: KNA**

Created: 5/31/2004 **Saved: 9/2/2010**

Steady state solution

Target SRT: 9.83333333333333 SRT: 9.83
Temperature: 20.0

Flowsheet



Configuration information for all Anaerobic Digester units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	Head space volume
Digester 1	0.3672	1963.5001	25.000	0.5
Digester 2	0.3672	1963.5001	25.000	0.5

Operating data Average (flow/time weighted as required)

Element name	Pressure [psi]	pH
Digester 1	14.9	7.0
Digester 2	14.9	7.0

Element name	Average Temperature
Digester 1	35.0
Digester 2	35.0

Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
OX-AX Switch	0.4300	5225.6947	11.000	Un-aerated
OX3	0.4300	5225.6947	11.000	1184
OX1	0.4300	5225.6947	11.000	1184
OX2	0.4300	5225.6947	11.000	1184
OX4	0.4300	5225.6947	11.000	1184
AX1	0.4300	5225.6947	11.000	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
OX-AX Switch	0
OX3	1.0
OX1	1.0
OX2	1.0
OX4	0.8
AX1	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
OX-AX Switch	2.5656	0.0432	0.8200	0.0410	10.0000
OX3	2.5656	0.0432	0.8200	0.0410	10.0000
OX1	2.5656	0.0432	0.8200	0.0410	10.0000
OX2	2.5656	0.0432	0.8200	0.0410	10.0000
OX4	2.5656	0.0432	0.8200	0.0410	10.0000
AX1	2.5656	0.0432	0.8200	0.0410	10.0000

Configuration information for all Effluent units

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Secondary Clarifier	5.2740	53819.5520	13.100

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Secondary Clarifier	Ratio	0.75

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Secondary Clarifier	Uses global setting	No	99.80	0.05

Configuration information for all COD Influent units

Operating data Average (flow/time weighted as required)

Element name	Inf
Time	0
Flow	2.58000001056688
Total COD mgCOD/L	776.00
Total Kjeldahl Nitrogen mgN/L	39.50
Total P mgP/L	10.00
Nitrate N mgN/L	0
pH	7.70
Alkalinity mmol/L	5.90
Inorganic S.S. mgISS/L	41.60
Calcium mg/L	40.00
Magnesium mg/L	20.00
Dissolved oxygen mg/L	0

Element name	Inf
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2200
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.7500
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0400
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.2000
Fna - Ammonia [gNH3-N/gTKN]	0.6300
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0050
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0100
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	0.1000
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	0.0001
FZbp - PAOs [gCOD/g of total COD]	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	0.0001

Configuration information for all Ideal primary settling tank units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
primary clarifiers	0.6508	8700.0000	10.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
primary clarifiers	Fraction	0.01

Element name	Percent removal	Blanket fraction
primary clarifiers	65.00	0.10

Configuration information for all Dewatering unit units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Thickening Centrifuge	Fraction	0.18
belt press	Fraction	0.08

Element name	Percent removal
Thickening Centrifuge	95.00
belt press	95.00

Configuration information for all Point clarifier units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
filters	Ratio	0.05

Element name	Percent removal
filters	99.90

Configuration information for all Sludge units

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
RAS	Flowrate [Side]	0.0750713822223086
secondary clarifier feed	Ratio	3.00

BioWin Album

Album page - Air

Elements	Total oxygen uptake rate [mg O/L/hr]	Carbonaceous OUR [mg O/L/hr]	Nitrogenous OUR [mg O/L/hr]	Net. nitrite production rate [mg N/L/hr]	Dissolved N2 gas production rate [mg N/L/hr]	Spec. dissolved N2 gas production rate per VSS [mg N/g VSS/hr]	Spec. dissolved N2 gas production per VASS [mg N/g VASS/hr]	OTE [%]	OTR [lb/hr]	SOTE [%]	Off gas flow rate (dry) [ft3/min]	Ammonia N [mg N/L]	Nitrate N [mg N/L]	Air supply rate [ft3/min (20 C, 1 atm)]	Air flow rate / diffuser [ft3/min (20 C, 1 atm)]	# of diffusers []
AX1	1.27	1.18	0.08	0.06	4.64	2.41	6.58	100.00	0	100.00	3.86	4.35	0.44	0	0	0
OX-AX Switch	0.00	0.00	0.00	-0.17	0.94	0.49	1.34	100.00	0	100.00	4.98	4.70	0.02	0	0	0
OX 1	22.99	12.21	10.78	0.44	0.30	0.16	0.42	9.45	89.09	25.73	913.82	2.98	1.03	903.17	0.76	1184.00
OX 2	19.23	9.76	9.47	0.02	0.23	0.12	0.33	9.97	69.00	27.16	665.02	1.68	2.09	662.79	0.56	1184.00
OX 3	15.81	8.71	7.11	-0.20	0.18	0.10	0.26	10.41	56.75	28.35	522.36	0.82	2.96	522.22	0.44	1184.00
OX 4	12.16	7.82	4.33	-0.14	0.16	0.08	0.23	11.49	42.30	30.48	352.55	0.39	3.46	352.57	0.30	1184.00

Album page - Volume

Elements	Liquid volume [Mil. Gal]
AX1	0.43
OX-AX Switch	0.43
OX1	0.43
OX2	0.43
OX3	0.43
OX4	0.43

Album page - Tables

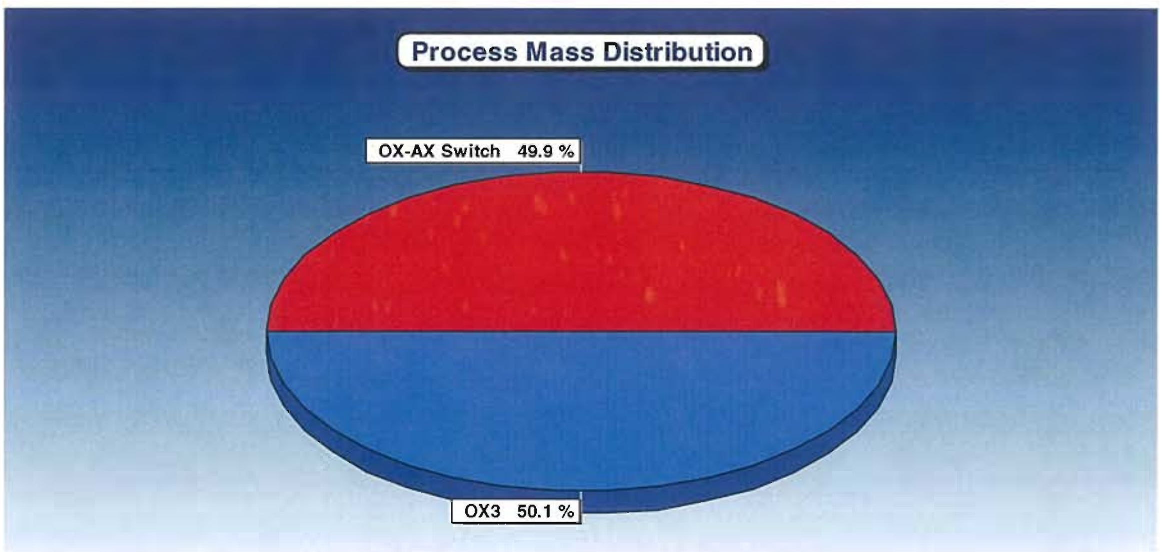
Elements	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Kjeldahl Nitrogen [mgN/L]	Total P [mgP/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total N [mgN/L]	PO4-P (Sol. & Me Complexed) [mgP/L]
primary	437.14	226.77	139.76	122.47	36.44	14.39	28.78	0.24	36.68	12.38

clarifiers										
AX1	2433.30	604.11	2528.79	1920.60	119.64	144.14	4.35	0.44	120.17	6.99
OX-AX Switch	2431.39	599.93	2518.12	1920.00	119.64	144.14	4.70	0.02	119.66	10.28
OX1	2421.31	595.48	2521.13	1917.90	118.21	144.14	2.98	1.03	119.49	8.64
OX2	2415.05	592.10	2522.99	1915.28	117.02	144.14	1.68	2.09	119.37	7.21
OX3	2409.94	588.99	2523.98	1912.67	116.16	144.14	0.82	2.96	119.27	6.06
Effluent	35.74	0.63	0.01	0.01	1.63	5.18	0.39	3.46	5.17	5.18

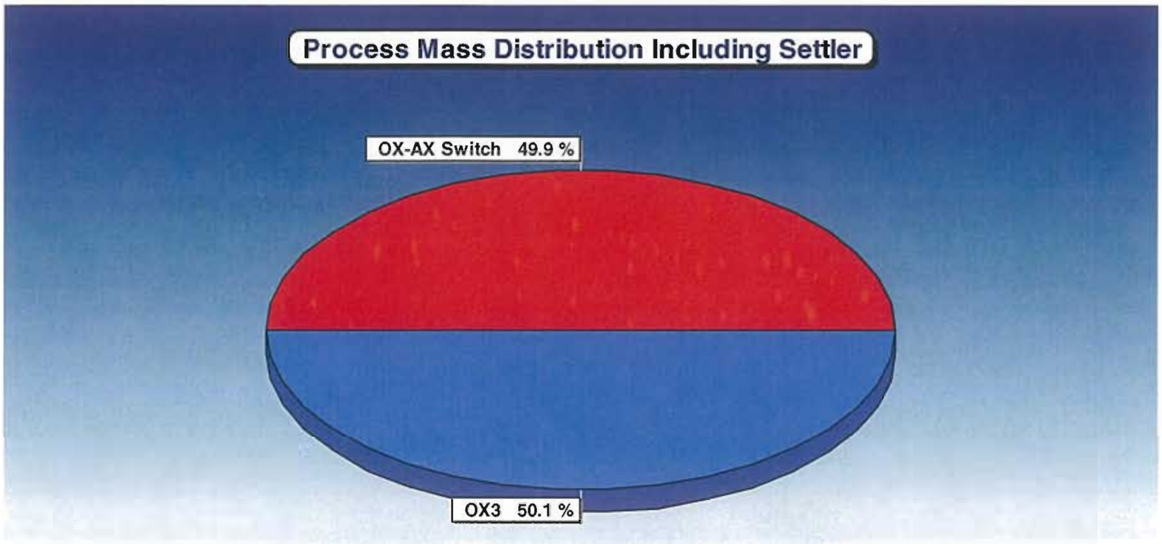
Album page - Tables

Elements	Total COD [lb /d]	Total Carbonaceous BOD [lb /d]	Total suspended solids [lb TSS/d]	Volatile suspended solids [lb VSS/d]	Total Kjeldahl Nitrogen [lb N/d]	Total N [lb N/d]	Soluble PO4-P [lb P/d]	Total P [lb P/d]
OX-AX Switch	384345.01	94835.15	398056.08	303506.76	18911.59	18914.99	1624.48	22785.07
OX3	380955.24	93105.62	398981.87	302348.05	18361.97	18853.16	957.52	22785.07
Effluent	768.68	13.65	0.20	0.15	35.16	111.10	111.41	111.42
Dewatered Sludge	5349.02	522.18	5686.23	4663.02	166.48	166.48	15.77	103.89

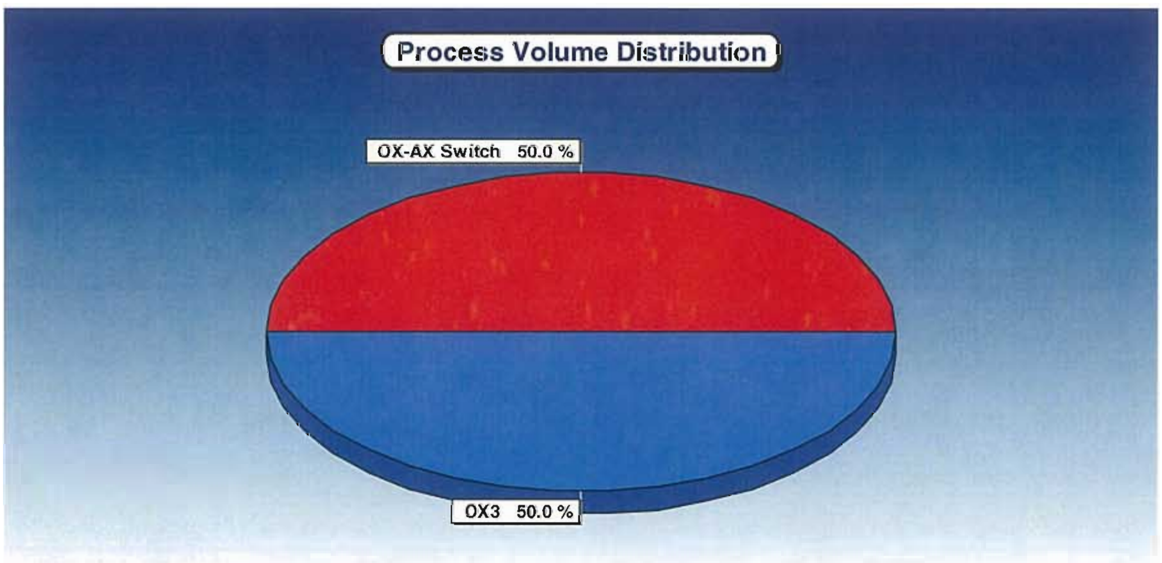
Album page - Mass Dist-Process Only



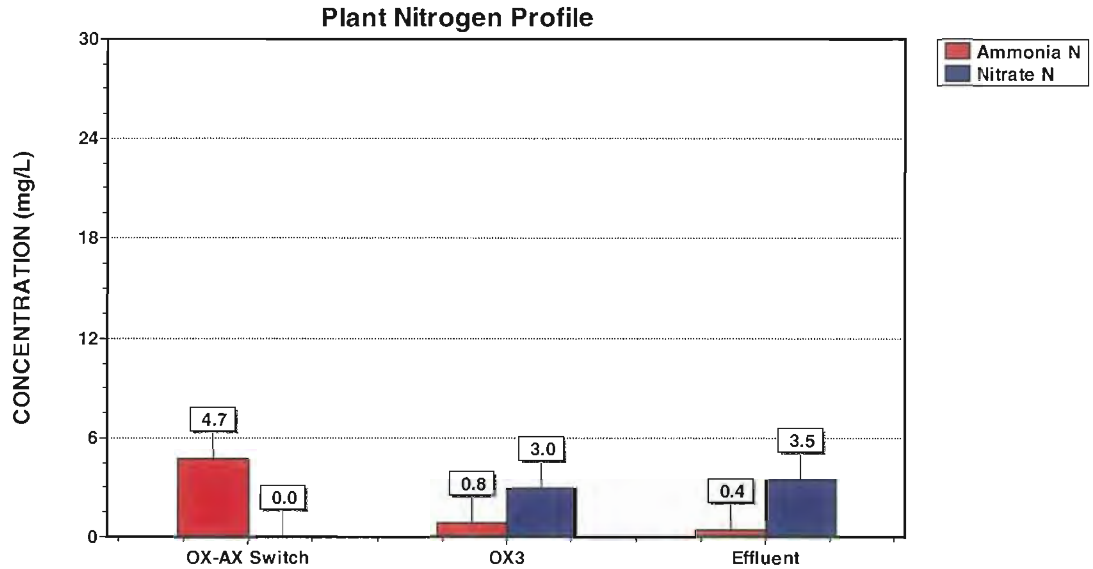
Album page - Mass Dist-Incl. Settler



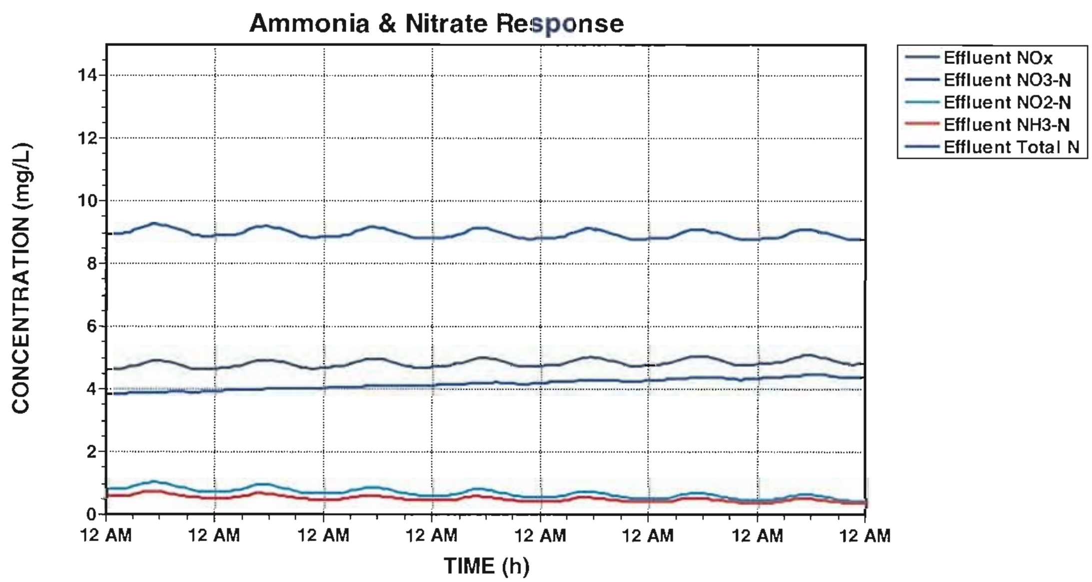
Album page - Volume Dist



Album page - N Profile



Album page - Dynamic Chart



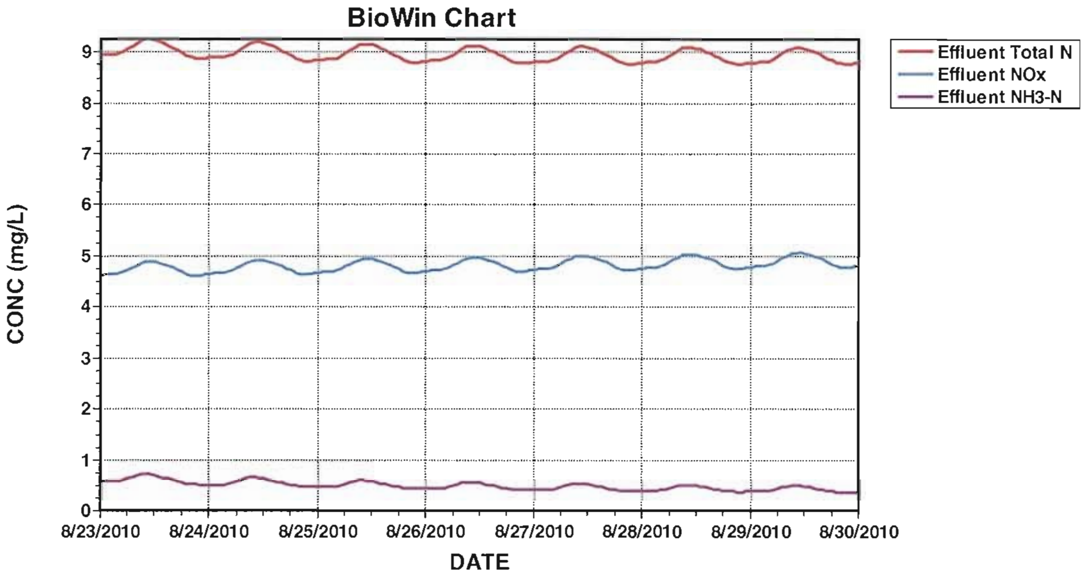
Album page - Page 8

OX-AX Switch			
Parameters	Conc. (mg/L)	Mass rate (lb/d)	Notes
Volatile suspended solids	1920.00	303506.76	
Total suspended solids	2518.12	398056.08	
Particulate COD	2388.78	377609.67	
Filtered COD	42.61	6735.33	
Total COD	2431.39	384345.01	
Soluble PO4-P	10.28	1624.48	
Total P	144.14	22785.07	
Filtered TKN	5.72	904.33	

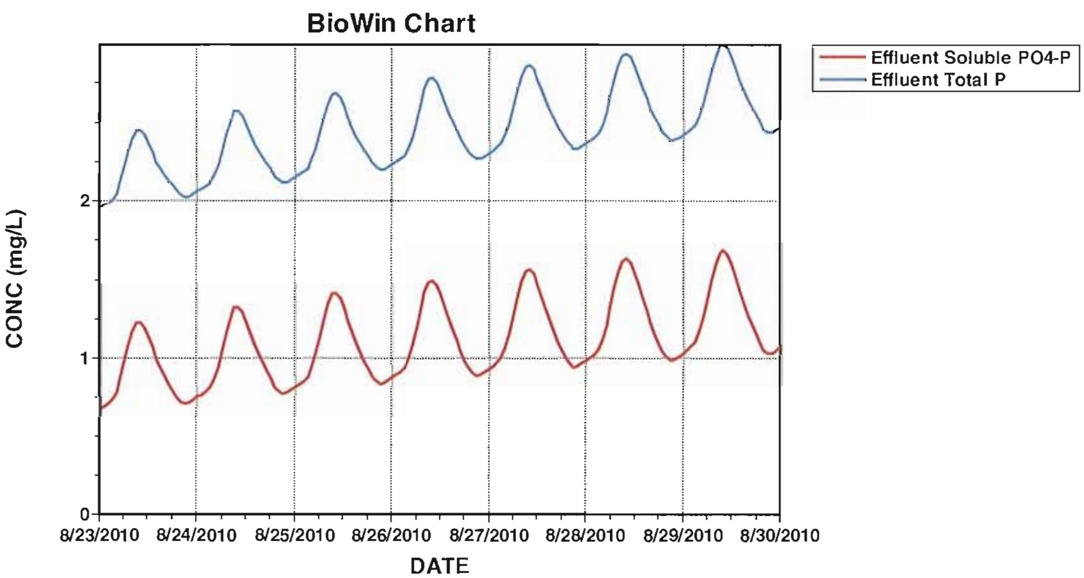
Particulate TKN	113.91	18007.26	
Total Kjeldahl Nitrogen	119.64	18911.59	
Filtered Carbonaceous BOD	2.62	414.69	
Total Carbonaceous BOD	599.93	94835.15	
Nitrite + Nitrate	0.02	3.40	
Total N	119.66	18914.99	
Total inorganic N	4.72	746.41	
Alkalinity	4.52	323.91	mmol/L and kmol/d
pH	7.00		
Volatile fatty acids	1.77	280.39	
Total precipitated solids	0	0.00	
Total inorganic suspended solids	598.12	94549.32	
Ammonia N	4.70	743.00	
Nitrate N	0.02	2.40	

Parameters	Value	Units
Hydraulic residence time	0.5	hours
Flow	18.94	mgd
MLSS	2518.12	mg/L
Total solids mass	9036.34	lb
Total readily biodegradable COD	3.67	mg/L
Total oxygen uptake rate	0.00	mgO/L/hr
Carbonaceous OUR	0.00	mgO/L/hr
Nitrogenous OUR	0.00	mgO/L/hr
Net. ammonia removal rate	-0.64	mgN/L/hr
Nitrate production rate	0.00	mgN/L/hr
Nitrite production rate	0.77	mgN/L/hr
Nitrate removal rate	0.77	mgN/L/hr
Nitrite removal rate	0.94	mgN/L/hr
Net. nitrate production rate	-0.77	mgN/L/hr
Net. nitrite production rate	-0.17	mgN/L/hr
Dissolved N2 gas production rate	0.94	mgN/L/hr
Spec. dissolved N2 gas production rate per VSS	0.49	mgN/gVSS/hr
Spec. dissolved N2 gas production per VASS	1.34	mgN/gVASS/hr
OTE	100.00	%
OTR	0	lb/hr
SOTE	100.00	%
SOTR	0	lb/hr
Air supply rate	0	ft3/min (20C, 1 atm)
Air flow rate / diffuser	0	ft3/min (20C, 1 atm)
# of diffusers	0	
Off gas flow rate (dry)	4.98	ft3/min
Oxygen content	0	%
Carbon dioxide content	60.81	%
Ammonia content	0.01	%
Actual DO sat. conc.	8.43	mg/L
Velocity gradient	82.88	1/s

Album page - EffTN



Album page - EffTP



Album page - ExportData

Elements Non-polyP heterotrophs [mgCOD/L] Anoxic methanol utilizers [mgCOD/L] Ammonia oxidizing biomass [mgCOD/L] Nitrite oxidizing biomass [mgCOD/L] Anaerobic ammonia oxidizers [mgCOD/L] PolyP heterotrophs [mgCOD/L] Propionic acetogens [mgCOD/L] Acetoclastic methanogens [mgCOD/L] Hydrogenotrophic methanogens [mgCOD/L] Endogenous products [mgCOD/L] Slowly bio. COD (part.) [mgCOD/L] Slowly bio. COD (colloid.) [mgCOD/L] Part. inert. COD [mgCOD/L] Part. bio. org. N [mgN/L] Part. bio. org. P [mgP/L] Part. inert N [mgN/L] Part. inert P [mgP/L] Stored PHA [mgCOD/L] Releasable stored polyP [mgP/L] Fixed stored polyP [mgP/L] PolyP bound cations [mg/L] Readily bio. COD (complex) [mgCOD/L] Acetate [mgCOD/L] Propionate [mgCOD/L] Methanol [mgCOD/L] Dissolved H2 [mgCOD/L] Dissolved methane [mg/L] Ammonia N [mgN/L] Sol. bio. org. N [mgN/L] Nitrite N [mgN/L] Nitrate N [mgN/L] Dissolved nitrogen gas [mgN/L] PO4-P (Sol. & Me

Complexed) [mgP/L] Sol. inert COD [mgCOD/L] Sol. inert TKN [mgN/L] Inorganic S.S. [mgISS/L]
Struvite [mgISS/L] Hydroxy-dicalcium-phosphate [mgISS/L] Hydroxy-apatite [mgISS/L] Magnesium [mg/L]
Calcium [mg/L] Metal [mg/L] Other Cations (strong bases) [meq/L] Other Anions (strong acids)
[meq/L] Total CO2 [mmol/L] User defined 1 [mg/L] User defined 2 [mg/L] User defined 3 [mgVSS/L]
User defined 4 [mgISS/L] Dissolved oxygen [mg/L] Flow [mgd] Liquid volume [Mil. Gal]
Temperature [deg. C] Volatile suspended solids [mgVSS/L] Total suspended solids [mgTSS/L]
Particulate COD [mg/L] Filtered COD [mg/L] Total COD [mg/L] Soluble PO4-P [mgP/L] Total P
[mgP/L] Filtered TKN [mgN/L] Particulate TKN [mgN/L] Total Kjeldahl Nitrogen [mgN/L] Filtered
Carbonaceous BOD [mg/L] Total Carbonaceous BOD [mg/L] Nitrite + Nitrate [mgN/L] Total N [mgN/L]
Total inorganic N [mgN/L] Alkalinity [mmol/L] pH [] Volatile fatty acids [mg/L] Total precipitated
solids [mgTSS/L] Total inorganic suspended solids [mgTSS/L]

Digester 1		1553.48	3.48	52.54	33.51	4.27	823.97	3.10	256.83	181.49	3534.76
	5111.33	0.01	12140.30	181.68	61.81	121.40	133.54	530.14	0.12	69.60	47.73
	0.10	171.50	1.30	0	0.02	28.46	351.42	0.36	0.00	0.00	0.08
	569.61	85.43	4.01	3254.10	0	0	0	121.85	67.99	0	14.34
	9.36	53.84	0	0	0	0	0.00	0.03	0.37	35.00	19814.90
	23678.88	24229.21	258.36	24487.57	569.61	973.66	355.79	750.31	1106.10	122.13	4761.72
	0.00	1106.10	351.42	25.23	7.00	172.80	0	3863.98			
Digester 2		362.87	2.34	22.88	14.59	3.26	579.36	3.34	192.92	122.90	3794.57
	1805.32	0.00	12140.30	82.18	26.76	121.40	133.54	372.91	0.00	48.94	33.63
	0.16	57.70	2.81	0	0.01	19.09	514.69	0.42	0.00	0.00	0.00
	653.53	122.13	6.57	3254.10	0	0	0	126.74	69.34	0	15.67
	10.46	65.73	0	0	0	0	0.00	0.03	0.37	35.00	16941.29
	20658.72	19417.56	182.80	19600.36	653.53	973.66	521.68	559.11	1080.79	42.85	1936.23
	0.00	1080.79	514.69	35.17	7.00	60.51	0	3717.43			
OX-AX Switch		739.02	0.26	22.38	14.01	0.34	222.04	0.07	0.15	0.19	510.81
	39.24	0.04	829.16	1.50	0.48	8.29	9.12	11.10	73.24	18.81	62.55
	1.90	0.51	1.27	0	4.43	0.04	4.70	0.58	0.01	0.02	17.93
	10.28	34.47	0.44	222.25	0	0	0	20.93	40.26	0	5.80
	5.01	5.98	0	0	0	0	0.00	18.94	0.43	20.00	1920.00
	2518.12	2388.78	42.61	2431.39	10.28	144.14	5.72	113.91	119.64	2.62	599.93
	0.02	119.66	4.72	4.52	7.00	1.77	0	598.12			
OX3	739.36	0.26	22.67	14.18	0.34	223.96	0.07	0.14	0.18	513.65	24.16
	0.00	829.16	1.30	0.41	8.29	9.12	5.97	77.24	18.98	65.38	0.99
	0.00	0.00	0	0.17	0.01	0.82	0.77	0.15	2.96	15.68	6.06
	34.69	0.45	222.25	0	0	0	19.95	39.99	0	5.75	5.00
	5.56	0	0	0	0	1.00	18.94	0.43	20.00	1912.67	2523.98
	2374.10	35.84	2409.94	6.06	144.14	2.05	114.11	116.16	0.70	588.99	3.11
	119.27	3.93	4.03	7.00	0.00	0	611.31				
OX1	740.69	0.26	22.52	14.07	0.34	222.87	0.07	0.15	0.19	511.76	32.71
	0.00	829.16	1.44	0.46	8.29	9.12	9.25	74.75	18.88	63.63	1.38
	0.02	0.05	0	1.30	0.02	2.98	0.69	0.25	1.03	16.35	8.64
	34.54	0.44	222.25	0	0	0	20.56	40.15	0	5.78	5.01
	5.79	0	0	0	0	1.00	18.94	0.43	20.00	1917.90	2521.13
	2384.03	37.29	2421.31	8.64	144.14	4.11	114.10	118.21	1.02	595.48	1.28
	119.49	4.26	4.31	7.00	0.07	0	603.23				
OX2	740.51	0.26	22.62	14.14	0.34	223.51	0.07	0.15	0.18	512.70	27.78
	0.00	829.16	1.37	0.43	8.29	9.12	7.47	76.11	18.94	64.59	1.12
	0.00	0.00	0	0.44	0.01	1.68	0.74	0.26	2.09	15.86	7.21
	34.61	0.45	222.25	0	0	0	20.22	40.06	0	5.76	5.00
	5.66	0	0	0	0	1.00	18.94	0.43	20.00	1915.28	2522.99
	2378.89	36.17	2415.05	7.21	144.14	2.87	114.15	117.02	0.79	592.10	2.35
	119.37	4.03	4.14	7.00	0.00	0	607.71				
OX4	737.51	0.26	22.67	14.19	0.34	224.25	0.07	0.14	0.18	514.59	21.58
	0.00	829.16	1.25	0.39	8.29	9.12	4.73	78.12	19.01	66.00	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18
	34.76	0.46	222.25	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	18.94	0.43	20.00	1910.12	2524.19
	2369.68	35.73	2405.41	5.18	144.14	1.63	114.01	115.65	0.63	586.05	3.53
	119.18	3.93	3.96	7.00	0.00	0	614.07				
AX1	741.60	0.26	22.42	14.04	0.34	222.19	0.07	0.15	0.18	510.35	42.65
	0.67	829.16	1.51	0.49	8.29	9.12	5.80	76.45	18.82	64.74	7.78
	0.25	0.09	0	0.85	0.03	4.35	0.76	0.10	0.44	17.80	6.99
	34.44	0.44	222.25	0	0	0	20.17	40.05	0	5.76	5.01
	6.00	0	0	0	0	0.00	18.94	0.43	20.00	1920.60	2528.79
	2389.23	44.08	2433.30	6.99	144.14	5.55	114.09	119.64	6.21	604.11	0.53
	120.17	4.89	4.46	7.00	0.34	0	608.20				
Effluent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18

	34.76	0.46	0.00	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	2.58	0	20.00	0.01	0.01
	0.01	35.73	35.74	5.18	5.18	1.63	0.00	1.63	0.63	0.63	3.53
	5.17	3.93	3.96	7.00	0.00	0	0.00				
MLR	737.51	0.26	22.67	14.19	0.34	224.25	0.07	0.14	0.18	514.59	21.58
	0.00	829.16	1.25	0.39	8.29	9.12	4.73	78.12	19.01	66.00	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18
	34.76	0.46	222.25	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	14.21	0	20.00	1910.12	2524.19
	2369.68	35.73	2405.41	5.18	144.14	1.63	114.01	115.65	0.63	586.05	3.53
	119.18	3.93	3.96	7.00	0.00	0	614.07				
secondary clarifier underflow			1717.41	0.61	52.79	33.05	0.79	522.21	0.15	0.33	0.42
	1198.30	50.26	0.00	1930.84	2.91	0.90	19.31	21.24	11.02	181.91	44.26
	153.69	0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46
	15.62	5.18	34.76	0.46	517.55	0	0	0	19.73	39.93	0
	5.74	5.00	5.51	0	0	0	0	0.80	2.03	0	20.00
	4448.04	5878.00	5518.20	35.73	5553.93	5.18	328.77	1.63	265.50	267.13	0.63
	1363.87	3.53	270.66	3.93	3.96	7.00	0.00	0	1429.96		
primary sludge		6453.64	6.30	19.66	14.58	6.39	159.27	6.24	16.20	12.55	480.53
	19970.11	78.44	13150.00	298.18	129.23	131.50	144.65	22.09	43.43	12.98	38.40
	133.65	24.23	0.03	0	0.01	0.22	28.78	3.53	0.00	0.24	15.79
	12.38	32.33	0.29	3524.74	0	0	0	21.19	40.33	0	5.86
	5.06	7.57	0	0	0	0	0.05	0.02	0	20.00	29309.84
	33447.75	40317.54	268.68	40586.22	12.38	493.85	32.60	918.93	951.53	166.94	14487.85
	0.24	951.77	29.02	6.10	7.00	24.26	0	4137.92			
recycles	63.13	0.04	2.03	1.27	0.05	22.85	0.03	1.52	0.97	71.66	15.84
	0.00	162.46	0.74	0.24	1.62	1.79	3.29	6.39	1.94	5.66	0.79
	8.25	0.40	0	0.07	2.73	73.92	0.73	0.06	2.96	13.39	97.87
	47.25	1.33	43.55	0.00	0.00	0.00	35.03	44.13	0	7.16	5.78
	14.12	0	0	0.00	0.00	0.69	0.22	0	20.00	288.28	367.48
	345.17	56.76	401.93	97.87	111.73	75.98	13.68	89.66	6.67	69.30	3.03
	92.69	76.95	8.36	7.00	8.65	0.00	79.20				
filter backwash		54.15	0.02	1.66	1.04	0.02	16.47	0.00	0.01	0.01	37.78
	1.58	0.00	60.88	0.09	0.03	0.61	0.67	0.35	5.74	1.40	4.85
	0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62
	5.18	34.76	0.46	16.32	0.00	0.00	0.00	19.73	39.93	0	5.74
	5.00	5.51	0	0	0.00	0.00	0.80	0.13	0	20.00	140.25
	185.34	174.00	35.73	209.73	5.18	15.38	1.63	8.37	10.01	0.63	43.62
	3.53	13.54	3.93	3.96	7.00	0.00	0.00	45.09			
digester feed		7539.47	5.17	120.67	76.96	5.58	1171.74	4.19	10.75	8.66	2760.27
	12516.46	48.76	12140.30	191.32	82.18	121.40	133.54	36.38	400.68	98.98	339.58
	83.41	15.06	0.02	0	0.03	0.14	18.04	2.49	0.03	1.46	15.73
	9.65	33.25	0.35	3254.10	0	0	0	20.64	40.18	0	5.82
	5.04	6.79	0	0	0	0	0.34	0.03	0	20.00	27355.98
	32865.53	36396.61	180.53	36577.14	9.65	973.66	20.88	1116.60	1137.48	104.01	11806.14
	1.49	1138.96	19.52	5.29	7.00	15.08	0.00	5509.55			
Thickened WAS		9323.10	3.32	286.60	179.43	4.27	2834.86	0.83	1.80	2.26	6505.06
	272.82	0.00	10481.72	15.79	4.91	104.82	115.30	59.85	987.50	240.25	834.33
	0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62
	5.18	34.76	0.46	2809.53	0.00	0.00	0.00	19.73	39.93	0	5.74
	5.00	5.51	0	0	0.00	0.00	0.80	0.01	0	20.00	24146.50
	31909.15	29955.94	35.73	29991.67	5.18	1761.81	1.63	1441.28	1442.92	0.63	7401.06
	3.53	1446.45	3.93	3.96	7.00	0.00	0.00	7762.65			
WAS	1717.41	0.61	52.79	33.05	0.79	522.21	0.15	0.33	0.42	1198.30	50.26
	0.00	1930.84	2.91	0.90	19.31	21.24	11.02	181.91	44.26	153.69	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18
	34.76	0.46	517.55	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	0.08	0	20.00	4448.04	5878.00
	5518.20	35.73	5553.93	5.18	328.77	1.63	265.50	267.13	0.63	1363.87	3.53
	270.66	3.93	3.96	7.00	0.00	0	1429.96				
AX1 feed	734.29	0.26	22.46	14.06	0.34	222.17	0.07	0.15	0.18	509.87	33.62
	11.52	829.16	1.42	0.46	8.29	9.12	4.70	77.38	18.83	65.38	20.39
	3.56	0.00	0	0.06	0.03	4.56	1.19	0.06	2.99	15.65	6.24
	34.40	0.43	222.25	0	0	0	19.95	39.99	0	5.76	5.01
	5.82	0	0	0	0	0.69	18.94	0	20.00	1909.52	2520.15
	2371.36	69.93	2441.29	6.24	144.14	6.18	113.47	119.65	25.05	613.55	3.05
	122.70	7.61	4.28	7.00	3.56	0	610.63				
influent with recycles			76.45	0.07	0.23	0.17	0.08	1.89	0.07	0.19	0.15
	5.69	236.57	78.44	155.78	3.53	1.53	1.56	1.71	0.26	0.51	0.15
	0.45	133.65	24.23	0.03	0	0.01	0.22	28.78	3.53	0.00	0.24

	15.79	12.38	32.33	0.29	41.75	0	0	0	21.19	40.33	0
	5.86	5.06	7.57	0	0	0	0	0.05	2.80	0	20.00
	347.21	396.23	477.61	268.68	746.29	12.38	18.08	32.60	10.89	43.48	166.94
	336.58	0.24	43.72	29.02	6.10	7.00	24.26	0	49.02		
primary clarifiers		26.97	0.03	0.08	0.06	0.03	0.67	0.03	0.07	0.05	2.01
	83.44	78.44	54.94	1.25	0.54	0.55	0.60	0.09	0.18	0.05	0.16
	133.65	24.23	0.03	0	0.01	0.22	28.78	3.53	0.00	0.24	15.79
	12.38	32.33	0.29	14.73	0	0	0	21.19	40.33	0	5.86
	5.06	7.57	0	0	0	0	0.05	2.78	0.65	20.00	122.47
	139.76	168.46	268.68	437.14	12.38	14.39	32.60	3.84	36.44	166.94	226.77
	0.24	36.68	29.02	6.10	7.00	24.26	0	17.29			
Thickening Centrifuge			104.09	0.04	3.20	2.00	0.05	31.65	0.01	0.02	0.03
	72.62	3.05	0.00	117.02	0.18	0.05	1.17	1.29	0.67	11.02	2.68
	9.31	0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46
	15.62	5.18	34.76	0.46	31.37	0	0	0	19.73	39.93	0
	5.74	5.00	5.51	0	0	0	0	0.80	0.06	0	20.00
	269.58	356.24	334.44	35.73	370.17	5.18	24.79	1.63	16.09	17.73	0.63
	83.25	3.53	21.26	3.93	3.96	7.00	0.00	0	86.66		
belt press	19.79	0.13	1.25	0.80	0.18	31.60	0.18	10.52	6.70	206.97	98.47
	0.00	662.17	4.48	1.46	6.62	7.28	20.34	0.00	2.67	1.83	0.16
	57.70	2.81	0	0.01	19.09	514.69	0.42	0.00	0.00	0.00	653.53
	122.13	6.57	177.49	0	0	0	126.74	69.34	0	15.67	10.46
	65.73	0	0	0	0	0.00	0.03	0	20.00	924.04	1126.80
	1059.10	182.80	1241.90	653.53	670.99	521.68	30.50	552.17	42.85	146.12	0.00
	552.17	514.69	35.05	7.00	60.51	0	202.76				
filters	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18
	34.76	0.46	0.00	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	2.58	0	20.00	0.01	0.01
	0.01	35.73	35.74	5.18	5.18	1.63	0.00	1.63	0.63	0.63	3.53
	5.17	3.93	3.96	7.00	0.00	0	0.00				
Dewatered Sludge		4138.33	26.70	260.92	166.41	37.23	6607.29	38.04	2200.22	1401.62	43275.46
	20588.92	0.00	138454.75		937.26	305.14	1384.55	1523.00	4252.84	0.00	558.12
	383.51	0.16	57.70	2.81	0	0.01	19.09	514.69	0.42	0.00	0.00
	0.00	653.53	122.13	6.57	37111.58	0.00	0.00	0.00	126.74	69.34	0
	15.67	10.46	65.73	0	0	0.00	0.00	0.00	0.00	0	20.00
	193208.00		235603.64		221448.73		182.80	221631.53		653.53	4304.49
	521.68	6376.38	6898.06	42.85	21636.03	0.00	6898.06	514.69	35.05	7.00	60.51
	0.00	42395.64									
RAS	1717.41	0.61	52.79	33.05	0.79	522.21	0.15	0.33	0.42	1198.30	50.26
	0.00	1930.84	2.91	0.90	19.31	21.24	11.02	181.91	44.26	153.69	0.89
	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62	5.18
	34.76	0.46	517.55	0	0	0	19.73	39.93	0	5.74	5.00
	5.51	0	0	0	0	0.80	1.95	0	20.00	4448.04	5878.00
	5518.20	35.73	5553.93	5.18	328.77	1.63	265.50	267.13	0.63	1363.87	3.53
	270.66	3.93	3.96	7.00	0.00	0	1429.96				
secondary clarifier feed			737.51	0.26	22.67	14.19	0.34	224.25	0.07	0.14	0.18
	514.59	21.58	0.00	829.16	1.25	0.39	8.29	9.12	4.73	78.12	19.01
	66.00	0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46
	15.62	5.18	34.76	0.46	222.25	0	0	0	19.73	39.93	0
	5.74	5.00	5.51	0	0	0	0	0.80	4.74	0	20.00
	1910.12	2524.19	2369.68	35.73	2405.41	5.18	144.14	1.63	114.01	115.65	0.63
	586.05	3.53	119.18	3.93	3.96	7.00	0.00	0	614.07		
AX2 feed	741.60	0.26	22.42	14.04	0.34	222.19	0.07	0.15	0.18	510.35	42.65
	0.67	829.16	1.51	0.49	8.29	9.12	5.80	76.45	18.82	64.74	7.78
	0.25	0.09	0	0.85	0.03	4.35	0.76	0.10	0.44	17.80	6.99
	34.44	0.44	222.25	0	0	0	20.17	40.05	0	5.76	5.01
	6.00	0	0	0	0	0.00	18.94	0	20.00	1920.60	2528.79
	2389.23	44.08	2433.30	6.99	144.14	5.55	114.09	119.64	6.21	604.11	0.53
	120.17	4.89	4.46	7.00	0.34	0	608.20				
Inf	77.60	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0	255.61
	85.20	155.20	3.77	1.64	1.55	1.71	0	0.01	0	0.01	145.11
	25.61	0	0	0	0	24.89	3.77	0	0	16.00	5.00
	31.04	0.20	41.60	0	0	0	20.00	40.00	0	5.75	5.00
	7.00	0	0	0	0	0	2.58	0	20.00	352.29	398.71
	489.04	286.96	776.00	5.00	10.00	28.86	10.64	39.50	180.77	359.65	0
	39.50	24.89	5.90	7.00	25.61	0	46.41				
influent	77.60	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0	255.61
	85.20	155.20	3.77	1.64	1.55	1.71	0	0.01	0	0.01	145.11

25.61	0	0	0	0	24.89	3.77	0	0	16.00	5.00
31.04	0.20	41.60	0	0	0	20.00	40.00	0	5.75	5.00
7.00	0	0	0	0	0	2.58	0	20.00	352.29	398.71
489.04	286.96	776.00	5.00	10.00	28.86	10.64	39.50	180.77	359.65	0
39.50	24.89	5.90	7.00	25.61	0	46.41				
Secondary Clarifier	2.58	0.00	0.08	0.05	0.00	0.78	0.00	0.00	0.00	1.80
0.08	0.00	2.90	0.00	0.00	0.03	0.03	0.02	0.27	0.07	0.23
0.89	0.00	0.00	0	0.08	0.00	0.39	0.78	0.07	3.46	15.62
5.18	34.76	0.46	0.78	0	0	0	19.73	39.93	0	5.74
5.00	5.51	0	0	0	0	0.80	2.71	5.27	20.00	6.69
8.83	8.29	35.73	44.03	5.18	5.67	1.63	0.40	2.03	0.63	2.68
3.53	5.56	3.93	3.96	7.00	0.00	0	2.15			

Global Parameters

AOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.90000	0.70000	1.0720
Substrate (NH4) half sat. [mgN/L]	0.70000	1.00000	1.0000
Aerobic decay rate [1/d]	0.17000	0.17000	1.0290
Anoxic/anaerobic decay rate [1/d]	0.08000	0.08000	1.0290
KiHNO2 [mmol/L]	0.00500	0.00500	1.0000

NOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.70000	0.70000	1.0600
Substrate (NO2) half sat. [mgN/L]	0.10000	0.10000	1.0000
Aerobic decay rate [1/d]	0.17000	0.17000	1.0290
Anoxic/anaerobic decay rate [1/d]	0.08000	0.08000	1.0290
KiNH3 [mmol/L]	0.07500	0.07500	1.0000

ANAMMOX

Name	Default	Value	
Max. spec. growth rate [1/d]	0.10000	0.10000	1.1000
Substrate (NH4) half sat. [mgN/L]	2.00000	2.00000	1.0000
Substrate (NO2) half sat. [mgN/L]	1.00000	1.00000	1.0000
Aerobic decay rate [1/d]	0.01900	0.01900	1.0290
Anoxic/anaerobic decay rate [1/d]	0.00950	0.00950	1.0290
Ki Nitrite [mgN/L]	1000.00000	1000.00000	1.0000
Nitrite sensitivity constant [L / (d mgN)]	0.01600	0.01600	1.0000

OHOs

Name	Default	Value	
Max. spec. growth rate [1/d]	3.20000	3.20000	1.0290
Substrate half sat. [mgCOD/L]	5.00000	5.00000	1.0000
Anoxic growth factor [-]	0.50000	0.50000	1.0000
Aerobic decay [1/d]	0.62000	0.62000	1.0290
Anoxic/anaerobic decay [1/d]	0.30000	0.30000	1.0290
Hydrolysis rate (AS) [1/d]	2.10000	2.10000	1.0290
Hydrolysis half sat. (AS) [-]	0.06000	0.06000	1.0000
Anoxic hydrolysis factor [-]	0.28000	0.28000	1.0000
Anaerobic hydrolysis factor [-]	0.50000	0.50000	1.0000
Adsorption rate of colloids [L/(mgCOD d)]	0.80000	0.80000	1.0290

Ammonification rate [L/(mgN d)]	0.04000	0.04000	1.0290
Assimilative nitrate/nitrite reduction rate [1/d]	0.50000	0.50000	1.0000
Fermentation rate [1/d]	3.20000	3.20000	1.0290
Fermentation half sat. [mgCOD/L]	5.00000	5.00000	1.0000
Anaerobic growth factor (AS) [-]	0.12500	0.12500	1.0000
Hydrolysis rate (AD) [1/d]	0.10000	0.10000	1.0500
Hydrolysis half sat. (AD) [mgCOD/L]	0.15000	0.15000	1.0000

Methylotrophs

Name	Default	Value	
Max. spec. growth rate of methanol utilizers [1/d]	1.30000	1.30000	1.0720
Methanol half sat. [mgCOD/L]	0.50000	0.50000	1.0000
Aerobic decay rate of methanol utilizers [1/d]	0.04000	0.04000	1.0290
Anoxic/anaerobic decay rate of methanol utilizers [1/d]	0.03000	0.03000	1.0290

PAOs

Name	Default	Value	
Max. spec. growth rate [1/d]	0.95000	0.95000	1.0000
Max. spec. growth rate, P-limited [1/d]	0.42000	0.42000	1.0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0.10000	0.10000	1.0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0.05000	0.05000	1.0000
Magnesium half sat. [mgMg/L]	0.10000	0.10000	1.0000
Cation half sat. [mmol/L]	0.10000	0.10000	1.0000
Calcium half sat. [mgCa/L]	0.10000	0.10000	1.0000
Aerobic decay rate [1/d]	0.10000	0.10000	1.0000
Anaerobic decay rate [1/d]	0.04000	0.04000	1.0000
Sequestration rate [1/d]	6.00000	6.00000	1.0000
Anoxic growth factor NO3 [-]	0.33000	0.33000	1.0000
Anoxic growth factor NO2 [-]	0.33000	0.33000	1.0000

Acetogens

Name	Default	Value	
Max. spec. growth rate [1/d]	0.25000	0.25000	1.0290
Substrate half sat. [mgCOD/L]	10.00000	10.00000	1.0000
Acetate inhibition [mgCOD/L]	10000.00000	10000.00000	1.0000
Decay rate [1/d]	0.05000	0.05000	1.0290
Aerobic decay rate [1/d]	0.52000	0.52000	1.0290

Methanogens

Name	Default	Value	
Acetoclastic Mu Max [1/d]	0.30000	0.30000	1.0290
H2-utilizing Mu Max [1/d]	1.40000	1.40000	1.0290
Acetoclastic Ks [mgCOD/L]	100.00000	100.00000	1.0000
Acetoclastic methanol Ks [mgCOD/L]	0.50000	0.50000	1.0000
H2-utilizing CO2 half sat. [mmol/L]	0.10000	0.10000	1.0000
H2-utilizing Ks [mgCOD/L]	0.10000	0.10000	1.0000
H2-utilizing methanol Ks [mgCOD/L]	0.50000	0.50000	1.0000
Acetoclastic propionic inhibition [mgCOD/L]	10000.00000	10000.00000	1.0000
Acetoclastic decay rate [1/d]	0.13000	0.13000	1.0290
Acetoclastic aerobic decay rate [1/d]	0.60000	0.60000	1.0290
H2-utilizing decay rate [1/d]	0.13000	0.13000	1.0290
H2-utilizing aerobic decay rate [1/d]	0.60000	0.60000	1.0290

pH

Name	Default	Value
Heterotrophs low pH limit [-]	4.00000	4.00000
Heterotrophs high pH limit [-]	10.00000	10.00000
Methanol utilizers low pH limit [-]	4.00000	4.00000
Methanol utilizers high pH limit [-]	10.00000	10.00000
Autotrophs low pH limit [-]	5.50000	5.50000
Autotrophs high pH limit [-]	9.50000	9.50000
PolyP heterotrophs low pH limit [-]	4.00000	4.00000
Poly P heterotrophs high pH limit [-]	10.00000	10.00000
Heterotrophs low pH limit (anaerobic) [-]	5.50000	5.50000
Heterotrophs high pH limit (anaerobic) [-]	8.50000	8.50000
Propionic acetogens low pH limit [-]	4.00000	4.00000
Propionic acetogens high pH limit [-]	10.00000	10.00000
Acetoclastic methanogens low pH limit [-]	5.00000	5.00000
Acetoclastic methanogens high pH limit [-]	9.00000	9.00000
H2-utilizing methanogens low pH limit [-]	5.00000	5.00000
H2-utilizing methanogens high pH limit [-]	9.00000	9.00000

Switches

Name	Default	Value
Heterotrophic DO half sat. [mgO2/L]	0.05000	0.05000
Aerobic denit. DO half sat. [mgO2/L]	0.05000	0.20000
Ammonia oxidizer DO half sat. [mgO2/L]	0.25000	0.25000
Nitrite oxidizer DO half sat. [mgO2/L]	0.50000	0.50000
Anaerobic ammonia oxidizer DO half sat. [mgO2/L]	0.01000	0.01000
Anoxic NO3 half sat. [mgN/L]	0.10000	0.10000
Anoxic NO2 half sat. (mgN/L)	0.01000	0.05000
NH3 nutrient half sat. [mgN/L]	1.0000E-4	1.0000E-4
PolyP half sat. [mgP/L]	0.01000	0.01000
VFA sequestration half sat. [mgCOD/L]	5.00000	5.00000
P uptake half sat. [mgP/L]	0.15000	0.10000
P nutrient half sat. [mgP/L]	0.00100	0.00100
Autotroph CO2 half sat. [mmol/L]	0.10000	0.01000
Heterotrophic Hydrogen half sat. [mgCOD/L]	1.00000	1.00000
Propionic acetogens Hydrogen half sat. [mgCOD/L]	5.00000	5.00000
Synthesis anion/cation half sat. [meq/L]	0.01000	0.01000

Common

Name	Default	Value
N in endogenous residue [mgN/mgCOD]	0.07000	0.07000
P in endogenous residue [mgP/mgCOD]	0.02200	0.02200
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1.60000	1.80000
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1.60000	1.00000

AOB

Name	Default	Value
Yield [mgCOD/mgN]	0.15000	0.15000
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

NOB

Name	Default	Value
Yield [mgCOD/mgN]	0.09000	0.09000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

ANAMMOX

Name	Default	Value
Yield [mgCOD/mgN]	0.11400	0.11400
Nitrate production [mgN/mgBiomassCOD]	2.28000	2.28000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

OHOs

Name	Default	Value
Yield (aerobic) [-]	0.66600	0.66600
Yield (fermentation, low H2) [-]	0.10000	0.10000
Yield (fermentation, high H2) [-]	0.10000	0.10000
H2 yield (fermentation low H2) [-]	0.35000	0.35000
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0.70000	0.70000
CO2 yield (fermentation, low H2) [-]	0.70000	0.70000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Yield (anoxic) [-]	0.54000	0.66600
Yield propionic (aerobic) [-]	0.64000	0.50000
Yield propionic (anoxic) [-]	0.46000	0.41000
Yield acetic (aerobic) [-]	0.60000	0.40000
Yield acetic (anoxic) [-]	0.43000	0.32000
Yield methanol (aerobic) [-]	0.50000	0.50000
Adsorp. max. [-]	1.00000	1.00000

Methylotrophs

Name	Default	Value
Yield (anoxic) [-]	0.40000	0.40000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

PAOs

Name	Default	Value
Yield (aerobic) [-]	0.63900	0.63900
Yield (anoxic) [-]	0.52000	0.54000
Aerobic P/PHA uptake [mgP/mgCOD]	0.95000	0.95000
Anoxic P/PHA uptake [mgP/mgCOD]	0.35000	0.35000
Yield of PHA on sequestration [-]	0.88900	0.88900
N in biomass [mgN/mgCOD]	0.07000	0.07000
N in sol. inert [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous part. [-]	0.25000	0.25000
Inert fraction of endogenous sol. [-]	0.20000	0.20000
P/Ac release ratio [mgP/mgCOD]	0.49000	0.49000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Yield of low PP [-]	0.94000	0.94000

Acetogens

Name	Default	Value
Yield [-]	0.10000	0.10000
H2 yield [-]	0.40000	0.40000
CO2 yield [-]	1.00000	1.00000
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

Methanogens

Name	Default	Value
Acetoclastic yield [-]	0.10000	0.10000
Methanol acetoclastic yield [-]	0.10000	0.10000
H2-utilizing yield [-]	0.10000	0.10000
Methanol H2-utilizing yield [-]	0.10000	0.10000
N in acetoclastic biomass [mgN/mgCOD]	0.07000	0.06800
N in H2-utilizing biomass [mgN/mgCOD]	0.07000	0.06800
P in acetoclastic biomass [mgP/mgCOD]	0.02200	0.02100
P in H2-utilizing biomass [mgP/mgCOD]	0.02200	0.02100
Acetoclastic fraction to endog. residue [-]	0.08000	0.08000
H2-utilizing fraction to endog. residue [-]	0.08000	0.08000
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

General

Name	Default	Value
Ash content of biomass (synthesis ISS) [%]	8.00000	8.00000
Molecular weight of other anions [mg/mmol]	35.50000	35.50000
Molecular weight of other cations [mg/mmol]	39.10000	39.10000
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0.30000	0.30000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0.30000	0.30000
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0.05000	0.05000
Cation to P mole ratio in organic phosphate [meq/mmolP]	0.01000	0.01000
Bubble rise velocity (anaerobic digester) [cm/s]	23.90000	23.90000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0.35000	0.35000
Anaerobic digester gas hold-up factor []	1.00000	1.00000
Tank head loss per metre of length (from flow) [m/m]	0.00250	0.00250

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17.00000	17.28000	1.0240
Kl for CO2 [m/d]	10.00000	10.00000	1.0240
Kl for NH3 [m/d]	1.00000	1.00000	1.0240
Kl for CH4 [m/d]	8.00000	8.00000	1.0240
Kl for N2 [m/d]	15.00000	15.00000	1.0240
Kl for O2 [m/d]	13.00000	13.00000	1.0240

Physico-chemical rates

Name	Default	Value	
Struvite precipitation rate [1/d]	3.0000E+10	3.0000E+10	1.0240
Struvite redissolution rate [1/d]	3.0000E+11	3.0000E+11	1.0240
Struvite half sat. [mgTSS/L]	1.00000	1.00000	1.0000
HDP precipitation rate [L/(molP d)]	1.0000E+8	1.0000E+8	1.0000
HDP redissolution rate [L/(mol P d)]	1.0000E+8	1.0000E+8	1.0000
HAP precipitation rate [molHDP/(L d)]	5.0000E-4	5.0000E-4	1.0000

Physico-chemical constants

Name	Default	Value
Struvite solubility constant [mol/L]	6.9180E-14	6.9180E-14
HDP solubility product [mol/L]	2.7500E-22	2.7500E-22
HDP half sat. [mgTSS/L]	1.00000	1.00000
Equilibrium soluble PO4 with Al dosing at pH 7 [mgP/L]	0.01000	0.01000
Al to P ratio [molAl/molP]	0.80000	0.80000
Al(OH)3 solubility product [mol/L]	1.2590E+9	1.2590E+9
AlHPO4+ dissociation constant [mol/L]	7.9430E-13	7.9430E-13
Equilibrium soluble PO4 with Fe dosing at pH 7 [mgP/L]	0.01000	0.01000
Fe to P ratio [molFe/molP]	1.60000	1.60000
Fe(OH)3 solubility product [mol/L]	0.05000	0.05000
FeH2PO4++ dissociation constant [mol/L]	5.0120E-22	5.0120E-22

Aeration

Name	Default	Value
Alpha (surf) OR Alpha F (diff) [-]	0.50000	0.50000
Beta [-]	0.95000	0.95000
Surface pressure [kPa]	101.32500	101.32500
Fractional effective saturation depth (Fed) [-]	0.32500	0.32500
Supply gas CO2 content [vol. %]	0.03500	0.03500
Supply gas O2 [vol. %]	20.95000	20.95000
Off-gas CO2 [vol. %]	2.00000	2.00000
Off-gas O2 [vol. %]	18.80000	18.80000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Surface turbulence factor [-]	2.00000	2.00000
Set point controller gain [-]	1.00000	1.00000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.3873	0.3873
Vesilind hindered zone settling parameter (K) [L/g]	0.3700	0.3700
Clarification switching function [mg/L]	100.0000	20.0000
Specified TSS conc.for height calc. [mg/L]	2500.0000	2500.0000
Maximum compactability constant [mg/L]	15000.0000	15000.0000

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.9341	0.9341
Maximum (practical) settling velocity (Vo') [ft/min]	0.6152	0.6152
Hindered zone settling parameter (Kh) [L/g]	0.4000	0.4000
Flocculent zone settling parameter (Kf) [L/g]	2.5000	2.5000
Maximum non-settleable TSS [mg/L]	20.0000	20.0000
Non-settleable fraction [-]	0.0010	0.0010
Specified TSS conc. for height calc. [mg/L]	2500.0000	2500.0000

Biofilm general

Name	Default	Value	
Attachment rate [g / (m2 d)]	80.00000	80.00000	1.0000
Attachment TSS half sat. [mg/L]	100.00000	100.00000	1.0000
Detachment rate [g/(m3 d)]	8.0000E+4	8.0000E+4	1.0000
Solids movement factor []	10.00000	10.00000	1.0000
Diffusion neta []	0.80000	0.80000	1.0000
Thin film limit [mm]	0.50000	0.50000	1.0000
Thick film limit [mm]	3.00000	3.00000	1.0000
Assumed Film thickness for tank volume correction (temp independant) [mm]	0.75000	0.75000	1.0000
Film surface area to media area ratio - Max.[ ]	1.00000	1.00000	1.0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4.00000	4.00000	1.0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Non-polyP heterotrophs	5.0000E+4	5.0000E+4	1.0000
Anoxic methanol utilizers	5.0000E+4	5.0000E+4	1.0000
Ammonia oxidizing biomass	1.0000E+5	1.0000E+5	1.0000
Nitrite oxidizing biomass	1.0000E+5	1.0000E+5	1.0000
Anaerobic ammonia oxidizers	5.0000E+4	5.0000E+4	1.0000
PolyP heterotrophs	5.0000E+4	5.0000E+4	1.0000
Propionic acetogens	5.0000E+4	5.0000E+4	1.0000
Acetoclastic methanogens	5.0000E+4	5.0000E+4	1.0000
Hydrogenotrophic methanogens	5.0000E+4	5.0000E+4	1.0000
Endogenous products	3.0000E+4	3.0000E+4	1.0000
Slowly bio. COD (part.)	5000.00000	5000.00000	1.0000
Slowly bio. COD (colloid.)	0	0	1.0000
Part. inert. COD	5000.00000	5000.00000	1.0000
Part. bio. org. N	0	0	1.0000
Part. bio. org. P	0	0	1.0000
Part. inert N	0	0	1.0000
Part. inert P	0	0	1.0000
Stored PHA	5000.00000	5000.00000	1.0000
Releasable stored polyP	1.1500E+6	1.1500E+6	1.0000
Fixed stored polyP	1.1500E+6	1.1500E+6	1.0000
PolyP bound cations	1.1500E+6	1.1500E+6	1.0000

Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.0000E+10	1.0000E+10	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
Inorganic S.S.	1.3000E+6	1.3000E+6	1.0000
Struvite	8.5000E+5	8.5000E+5	1.0000
Hydroxy-dicalcium-phosphate	1.1500E+6	1.1500E+6	1.0000
Hydroxy-apatite	1.6000E+6	1.6000E+6	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.0000E+10	1.0000E+10	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	5.0000E+4	5.0000E+4	1.0000
User defined 4	5.0000E+4	5.0000E+4	1.0000
Dissolved oxygen	0	0	1.0000

Effective diffusivities [m2/s]

Name	Default	Value	
Non-polyP heterotrophs	5.0000E-14	5.0000E-14	1.0290
Anoxic methanol utilizers	5.0000E-14	5.0000E-14	1.0290
Ammonia oxidizing biomass	5.0000E-14	5.0000E-14	1.0290
Nitrite oxidizing biomass	5.0000E-14	5.0000E-14	1.0290
Anaerobic ammonia oxidizers	5.0000E-14	5.0000E-14	1.0290
PolyP heterotrophs	5.0000E-14	5.0000E-14	1.0290
Propionic acetogens	5.0000E-14	5.0000E-14	1.0290
Acetoclastic methanogens	5.0000E-14	5.0000E-14	1.0290
Hydrogenotrophic methanogens	5.0000E-14	5.0000E-14	1.0290
Endogenous products	5.0000E-14	5.0000E-14	1.0290
Slowly bio. COD (part.)	5.0000E-14	5.0000E-14	1.0290
Slowly bio. COD (colloid.)	6.9000E-11	6.9000E-11	1.0290
Part. inert. COD	5.0000E-14	5.0000E-14	1.0290
Part. bio. org. N	5.0000E-14	5.0000E-14	1.0290
Part. bio. org. P	5.0000E-14	5.0000E-14	1.0290
Part. inert N	5.0000E-14	5.0000E-14	1.0290
Part. inert P	5.0000E-14	5.0000E-14	1.0290
Stored PHA	5.0000E-14	5.0000E-14	1.0290
Releasable stored polyP	5.0000E-14	5.0000E-14	1.0290
Fixed stored polyP	5.0000E-14	5.0000E-14	1.0290
PolyP bound cations	5.0000E-14	5.0000E-14	1.0290
Readily bio. COD (complex)	6.9000E-10	6.9000E-10	1.0290
Acetate	1.2400E-9	1.2400E-9	1.0290
Propionate	8.3000E-10	8.3000E-10	1.0290
Methanol	1.6000E-9	1.6000E-9	1.0290
Dissolved H2	5.8500E-9	5.8500E-9	1.0290
Dissolved methane	1.9625E-9	1.9625E-9	1.0290
Ammonia N	2.0000E-9	2.0000E-9	1.0290
Sol. bio. org. N	1.3700E-9	1.3700E-9	1.0290
Nitrite N	2.9800E-9	2.9800E-9	1.0290
Nitrate N	2.9800E-9	2.9800E-9	1.0290
Dissolved nitrogen gas	1.9000E-9	1.9000E-9	1.0290
PO4-P (Sol. & Me Complexed)	2.0000E-9	2.0000E-9	1.0290

Sol. inert COD	6.9000E-10	6.9000E-10	1.0290
Sol. inert TKN	6.8500E-10	6.8500E-10	1.0290
Inorganic S.S.	5.0000E-14	5.0000E-14	1.0290
Struvite	5.0000E-14	5.0000E-14	1.0290
Hydroxy-dicalcium-phosphate	5.0000E-14	5.0000E-14	1.0290
Hydroxy-apatite	5.0000E-14	5.0000E-14	1.0290
Magnesium	7.2000E-10	7.2000E-10	1.0290
Calcium	7.2000E-10	7.2000E-10	1.0290
Metal	4.8000E-10	4.8000E-10	1.0290
Other Cations (strong bases)	1.4400E-9	1.4400E-9	1.0290
Other Anions (strong acids)	1.4400E-9	1.4400E-9	1.0290
Total CO2	1.9600E-9	1.9600E-9	1.0290
User defined 1	6.9000E-10	6.9000E-10	1.0290
User defined 2	6.9000E-10	6.9000E-10	1.0290
User defined 3	5.0000E-14	5.0000E-14	1.0290
User defined 4	5.0000E-14	5.0000E-14	1.0290
Dissolved oxygen	2.5000E-9	2.5000E-9	1.0290

EPS Strength coefficients [ ]

Name	Default	Value	
Non-polyP heterotrophs	1.00000	1.00000	1.0000
Anoxic methanol utilizers	1.00000	1.00000	1.0000
Ammonia oxidizing biomass	1.00000	1.00000	1.0000
Nitrite oxidizing biomass	1.00000	1.00000	1.0000
Anaerobic ammonia oxidizers	1.00000	1.00000	1.0000
PolyP heterotrophs	1.00000	1.00000	1.0000
Propionic acetogens	1.00000	1.00000	1.0000
Acetoclastic methanogens	1.00000	1.00000	1.0000
Hydrogenotrophic methanogens	1.00000	1.00000	1.0000
Endogenous products	1.00000	1.00000	1.0000
Slowly bio. COD (part.)	1.00000	1.00000	1.0000
Slowly bio. COD (colloid.)	0	0	1.0000
Part. inert. COD	1.00000	1.00000	1.0000
Part. bio. org. N	1.00000	1.00000	1.0000
Part. bio. org. P	1.00000	1.00000	1.0000
Part. inert N	1.00000	1.00000	1.0000
Part. inert P	1.00000	1.00000	1.0000
Stored PHA	1.00000	1.00000	1.0000
Releasable stored polyP	1.00000	1.00000	1.0000
Fixed stored polyP	1.00000	1.00000	1.0000
PolyP bound cations	1.00000	1.00000	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.00000	1.00000	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
Inorganic S.S.	0.33000	0.33000	1.0000
Struvite	1.00000	1.00000	1.0000
Hydroxy-dicalcium-phosphate	1.00000	1.00000	1.0000
Hydroxy-apatite	1.00000	1.00000	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.00000	1.00000	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000

User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	1.00000	1.00000	1.0000
User defined 4	1.00000	1.00000	1.0000
Dissolved oxygen	0	0	1.0000

Average Design Flow and Loads with one aeration train out of service.

APPENDIX B

LAYER AND SURVEY DATUM REQUIREMENTS

CITY OF PRESCOTT
Everybody's Hometown

PUBLIC WORKS DEPARTMENT
430 N VIRGINIA ST, PRESCOTT, AZ 86302
(928) 777-1130 (F) 928-771-5929

LAYER AND SURVEY DATUM REQUIREMENTS

When submitting survey datum and layer information for engineering plans that are to be submitted to the City of Prescott (i.e.: final plat, preliminary plat and revision of plat, improvement plans for subdivision and commercial site improvements, as-built plans, etc.) those plans must meet the following survey datum and layer requirements:

1. Datum will be in international feet for horizontal and vertical, NAVD 88 for vertical and City of Prescott co-ordinates for horizontal. Please refer to **Exhibit A** titled, "City of Prescott Survey Datum Requirements."

2. A survey block or note listing two on-site points conforming to "City of Prescott Survey Datum Requirements" must be provided. These two points must have a Northing, Easting and a NAVD 88 elevation.

3. Centerline monuments should be a rebar in a hand hole at all PC's, PT's and intersections. Right-of-Way monuments should be a rebar in concrete at PC's, PT's and angle points. See City of Prescott Standard detail 120-1P entitled, "Survey Marker" as published for downloading on the City of Prescott website: http://www.cityofprescott.net/services/

4. Works will be submitted in their entirety in digital electronic format which is compatible with the city's system as follows: CADD-- .DGN (microstation), .DWG (Auto CADD), .DXF (generic) and must conform to the city's layer and feature requirements as published for downloading on the City of Prescott website: http://www.cityofprescott.net/services/

Please direct questions concerning these requirements to:

City of Prescott
Public Works Department
Jon Jahnke
(928) 777-1130
E-mail: jon.jahnke@prescott-az.gov

CITY OF PRESCOTT
Everybody's Hometown

CITY OF PRESCOTT
PUBLIC WORKS DEPARTMENTS
430 N. VIRGINIA ST, PRESCOTT, AZ 86302
(928) 777-1130 (F) 928-771-5929

"EXHIBIT A"

"CITY OF PRESCOTT SURVEY DATUM REQUIREMENTS"			
COORDINATE UNITS:	International Feet		
DISTANCE UNITS:	International Feet		
HEIGHT UNITS:	International Feet		
VERTICAL DATUM:	NAVD 88		
STATE PLANE			
COORDINATE SYSTEM:	US State Plane 1983		
DATUM:	(WGS 84)		
ZONE:	Arizona Central 0202		
GEOID MODEL:	GEOID99 (Conus)		
CITY OF PRESCOTT – CONVERSION FROM STATE PLANE			
NORTHING:	(State Plane x 1.000329975) – 701,456.0090		
EASTING:	(State Plane x 1.000329975) + 69,457.2499		
STATE PLANE – CONVERSION FROM CITY OF PRESCOTT			
NORTHING:	(City of Prescott + 701,456.0090) x 0.999670134		
EASTING:	(City of Prescott – 69,457.2499) x 0.999670134		
EXAMPLE CITY OF PRESCOTT MINGO BASE			
LATITUDE	34°	34'	29.27969" N
LONGITUDE	112°	28'	48.72638" W
HEIGHT	5582.412'		

STATE PLANE	**COORDINATES**	**CITY OF PRESCOTT GRID**
NORTHING	1,301,026.703	600,000.0000
EASTING	530,367.742	600,000.0000
ELEVATION	5,673.955'	5,673.955'
Control provided by the City of Prescott will be in the City of Prescott coordinate system.		
INTERNATIONAL FEET & U.S. FEET CONVERSIONS		
U.S. Feet to International Feet	U.S. Feet x 1.00000200	
International Feet to U.S. Feet	International feet x 0.99999800	

1. When converting elevations, the difference is negligible; 0.011 , For example: 5673.955 International Feet = 5673.944 U.S. Feet.
2. When converting State Plane, the difference is unacceptable:
   Northing: 1,301,026.703 International Feet = 1,301,024.101 U.S. Feet
   Easting: 530,367.742 International Feet = 530,366.681 U.S. Feet
   The difference in coordinates is 2.602 feet in the Northings and 1.061 feet in the Eastings which is a locational difference of 2.810 feet.

BioWin user and configuration data

Project details

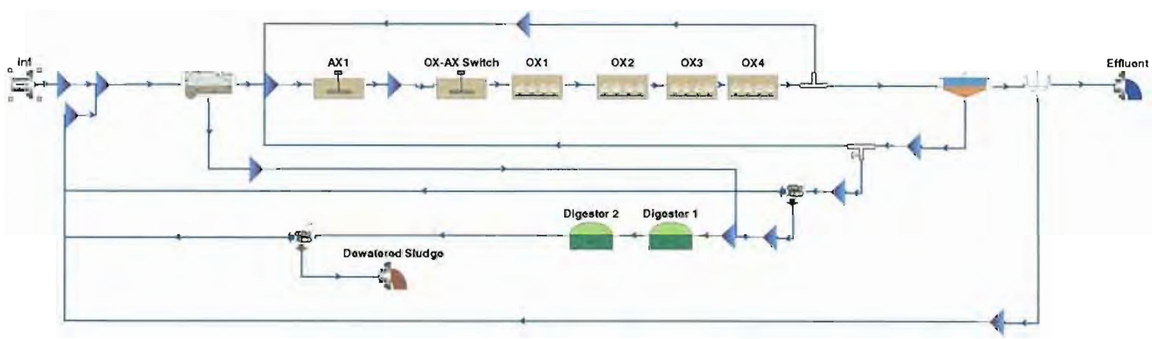
Project name: Max Month Summer **Project ref.: BW3**
Plant name: Sundog WWTP **User name: KNA**

Created: 5/31/2004 **Saved: 9/2/2010**

Steady state solution

Target SRT: 8.5 **SRT: 8.50**
Temperature: 20.0

Flowsheet



Configuration information for all Anaerobic Digester units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	Head space volume
Digester 1	0.3672	1963.5001	25.000	0.5
Digester 2	0.3672	1963.5001	25.000	0.5

Operating data Average (flow/time weighted as required)

Element name	Pressure [psi]	pH
Digester 1	14.9	7.0
Digester 2	14.9	7.0

Element name	Average Temperature
Digester 1	35.0
Digester 2	35.0

Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
OX-AX Switch	0.4300	5225.6947	11.000	Un-aerated
OX3	0.4300	5225.6947	11.000	1184
OX1	0.4300	5225.6947	11.000	1184
OX2	0.4300	5225.6947	11.000	1184
OX4	0.4300	5225.6947	11.000	1184
AX1	0.4300	5225.6947	11.000	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
OX-AX Switch	0
OX3	1.0
OX1	1.0
OX2	1.0
OX4	0.8
AX1	0

Aeration equipment parameters

Element name	k1 in *C* = k1(PC)^0.25 + k2	*k2 in C* = k1(PC)^0.25 + k2	*Y in Kla = C Usg* ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
OX-AX Switch	2.5656	0.0432	0.8200	0.0410	10.0000
OX3	2.5656	0.0432	0.8200	0.0410	10.0000
OX1	2.5656	0.0432	0.8200	0.0410	10.0000
OX2	2.5656	0.0432	0.8200	0.0410	10.0000
OX4	2.5656	0.0432	0.8200	0.0410	10.0000
AX1	2.5656	0.0432	0.8200	0.0410	10.0000

Configuration information for all Effluent units

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Secondary Clarifier	5.2740	53819.5520	13.100

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Secondary Clarifier	Ratio	0.75

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Secondary Clarifier	Uses global setting	No	99.80	0.05

Configuration information for all COD Influent units

Operating data Average (flow/time weighted as required)

Element name	Inf
Time	0
Flow	2.58000001056688
Total COD mgCOD/L	1351.00
Total Kjeldahl Nitrogen mgN/L	50.00
Total P mgP/L	12.00
Nitrate N mgN/L	0
pH	7.70
Alkalinity mmol/L	5.90
Inorganic S.S. mgISS/L	74.20
Calcium mg/L	40.00
Magnesium mg/L	20.00
Dissolved oxygen mg/L	0

Element name	Inf
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2200
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.7500
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0600
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.2000
Fna - Ammonia [gNH3-N/gTKN]	0.6300
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0050
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0100
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	0.1000
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	0.0001
FZbp - PAOs [gCOD/g of total COD]	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	0.0001

Configuration information for all Ideal primary settling tank units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
primary clarifiers	0.6508	8700.0000	10.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
primary clarifiers	Fraction	0.01

Element name	Percent removal	Blanket fraction
primary clarifiers	65.00	0.10

Configuration information for all Dewatering unit units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Thickening Centrifuge	Fraction	0.18
belt press	Fraction	0.08

Element name	Percent removal
Thickening Centrifuge	95.00
belt press	95.00

Configuration information for all Point clarifier units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
filters	Ratio	0.05

Element name	Percent removal
filters	99.90

Configuration information for all Sludge units

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
RAS	Flowrate [Side]	0.0866581118727797
secondary clarifier feed	Ratio	3.00

BioWin Album

Album page - Air

Elements	Total oxygen uptake rate [mg O/L/hr]	Carbonaceous OUR [mg O/L/hr]	Nitrogenous OUR [mg O/L/hr]	Net. nitrite production rate [mg N/L/hr]	Dissolved N2 gas production rate [mg N/L/hr]	Spec. dissolved N2 gas production rate per VSS [mg N/g VSS/hr]	Spec. dissolved N2 gas production per VASS [mg N/g VASS/hr]	OTE [%]	OTR [lb/hr]	SOTE [%]	Off gas flow rate (dry) [ft3/min]	Ammonia N [mg N/L]	Nitrate N [mg N/L]	Air supply rate [ft3/min (20 C, 1 atm)]	Air flow rate / diffuser [ft3/min (20 C, 1 atm)]	# of diffusers []
AX1	1.27	1.22	0.05	-0.06	5.73	1.92	4.79	100.00	0	100.00	5.33	5.55	0.12	0	0	0
OX-AX Switch	0.00	0.00	0.00	-0.06	0.27	0.09	0.23	100.00	0	100.00	7.51	5.96	0.00	0	0	0
OX 1	31.33	19.20	12.13	0.52	0.43	0.14	0.36	8.87	119.01	24.15	1313.81	3.73	1.09	1285.59	1.09	1184.00
OX 2	26.78	15.97	10.81	0.05	0.35	0.12	0.29	9.27	96.10	25.26	998.01	2.03	2.24	992.80	0.84	1184.00
OX 3	22.14	14.03	8.11	-0.24	0.28	0.09	0.23	9.67	79.45	26.33	787.48	0.92	3.20	787.18	0.66	1184.00
OX 4	17.00	12.36	4.64	-0.19	0.24	0.08	0.20	10.66	59.69	28.26	536.09	0.38	3.71	536.48	0.45	1184.00

Album page - Volume

Elements	Liquid volume [Mil. Gal]
AX1	0.43
OX-AX Switch	0.43
OX1	0.43
OX2	0.43
OX3	0.43
OX4	0.43

Album page - Tables

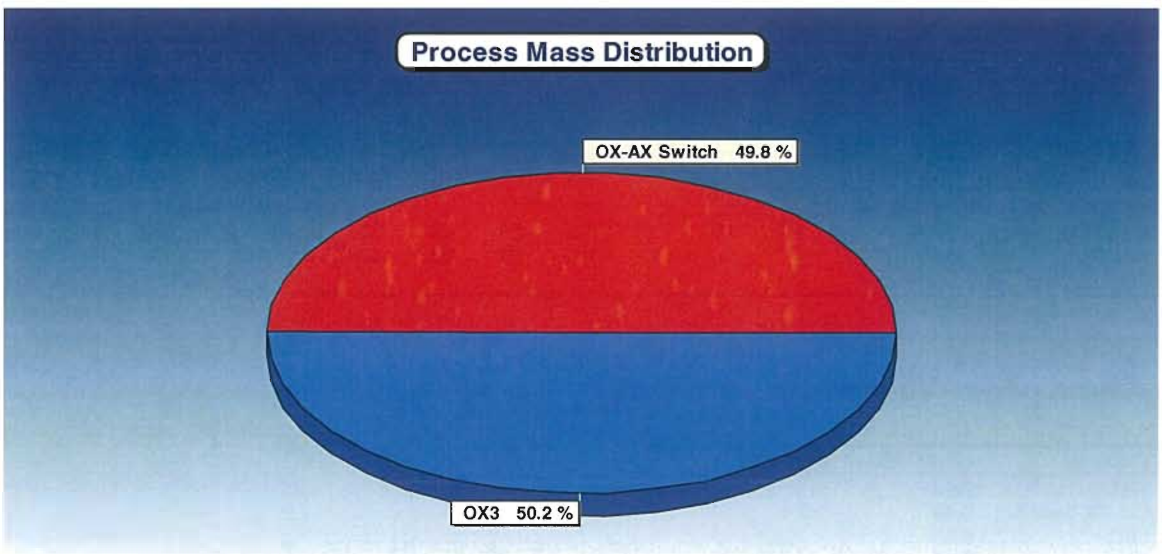
Elements	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Kjeldahl Nitrogen [mgN/L]	Total P [mgP/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total N [mgN/L]	PO4-P (Sol. & Me Complexed) [mgP/L]

primary clarifiers	773.81	385.30	240.19	208.51	46.14	29.30	37.13	0.26	46.41	26.33
AX1	3836.95	1017.82	4368.86	2982.67	186.23	366.67	5.55	0.12	186.38	10.92
OX-AX Switch	3835.01	1010.39	4345.11	2983.20	186.23	366.67	5.96	0.00	186.23	18.80
OX1	3814.65	1003.62	4358.21	2979.22	184.62	366.67	3.73	1.09	186.00	13.25
OX2	3803.62	998.11	4368.68	2974.97	183.25	366.67	2.03	2.24	185.80	8.47
OX3	3795.21	993.08	4376.54	2970.89	182.27	366.67	0.92	3.20	185.65	4.60
Effluent	93.52	0.66	0.02	0.01	2.03	1.69	0.38	3.71	5.82	1.69

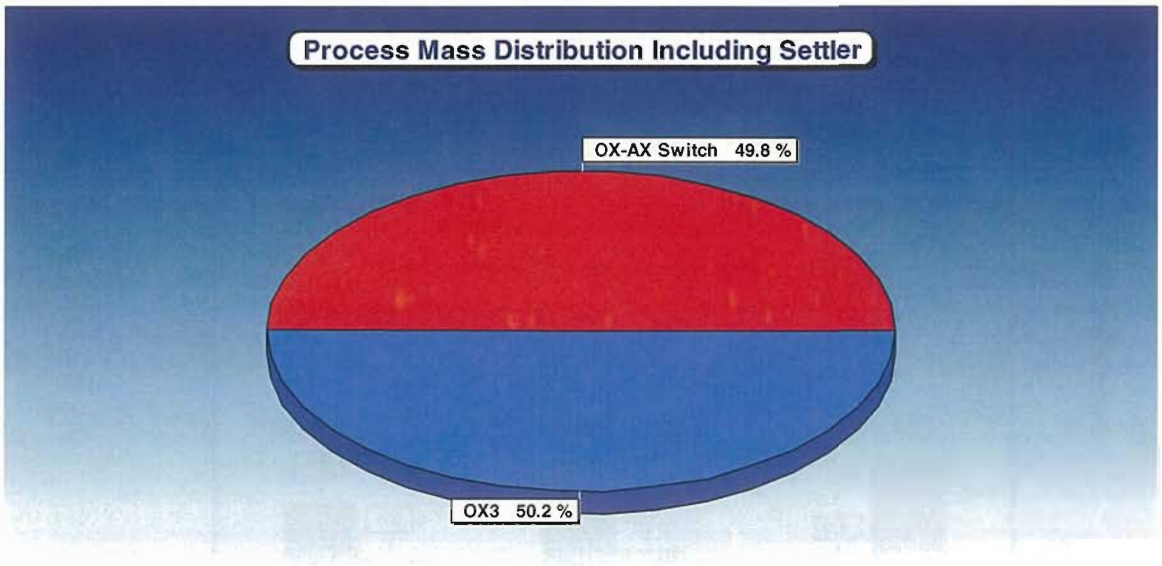
Album page - Tables

Elements	Total COD [lb /d]	Total Carbonaceous BOD [lb /d]	Total suspended solids [lb TSS/d]	Volatile suspended solids [lb VSS/d]	Total Kjeldahl Nitrogen [lb N/d]	Total N [lb N/d]	Soluble PO4-P [lb P/d]	Total P [lb P/d]
OX-AX Switch	606183.81	159707.58	686813.12	471542.05	29436.04	29436.72	2972.19	57958.07
OX3	599892.52	156972.05	691781.33	469595.22	28811.02	29344.74	727.64	57958.07
Effluent	2011.13	14.17	0.35	0.23	43.75	125.12	36.28	36.31
Dewatered Sludge	9549.67	1094.63	10184.09	8276.63	290.19	290.19	44.18	222.06

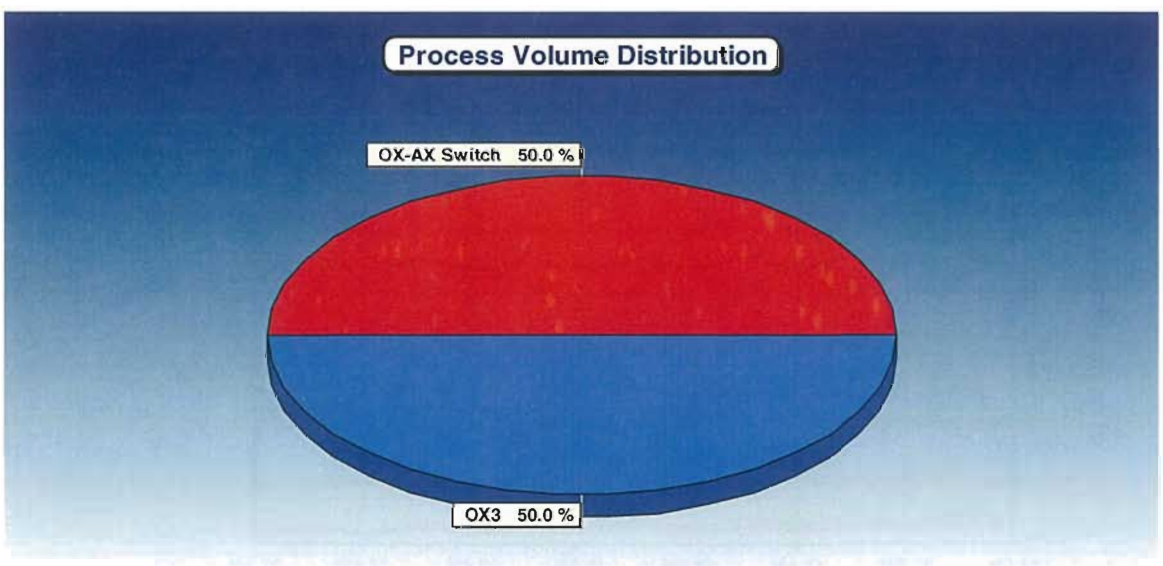
Album page - Mass Dist-Process Only



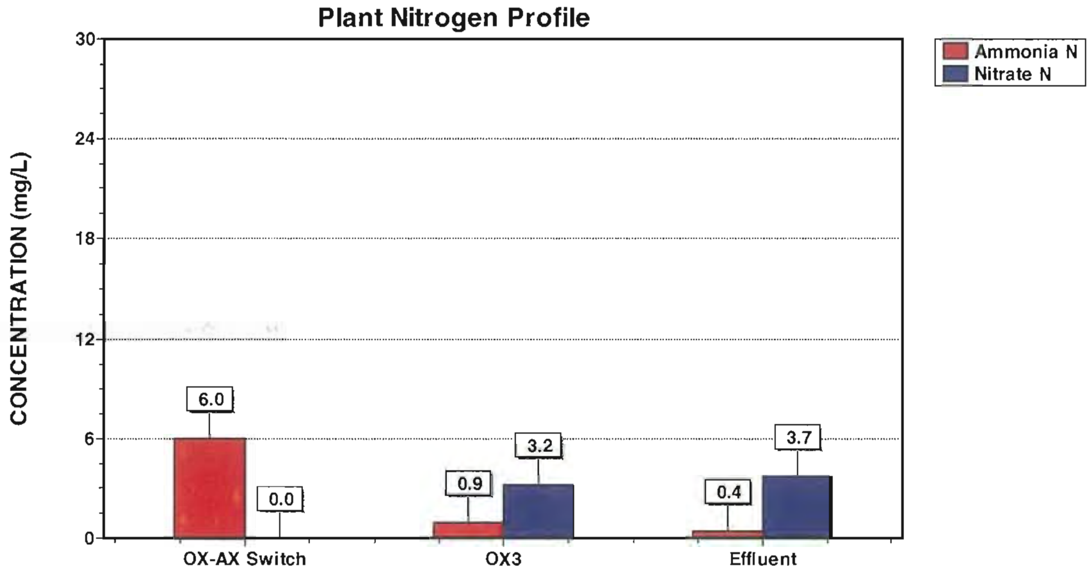
Album page - Mass Dist-Incl. Settler



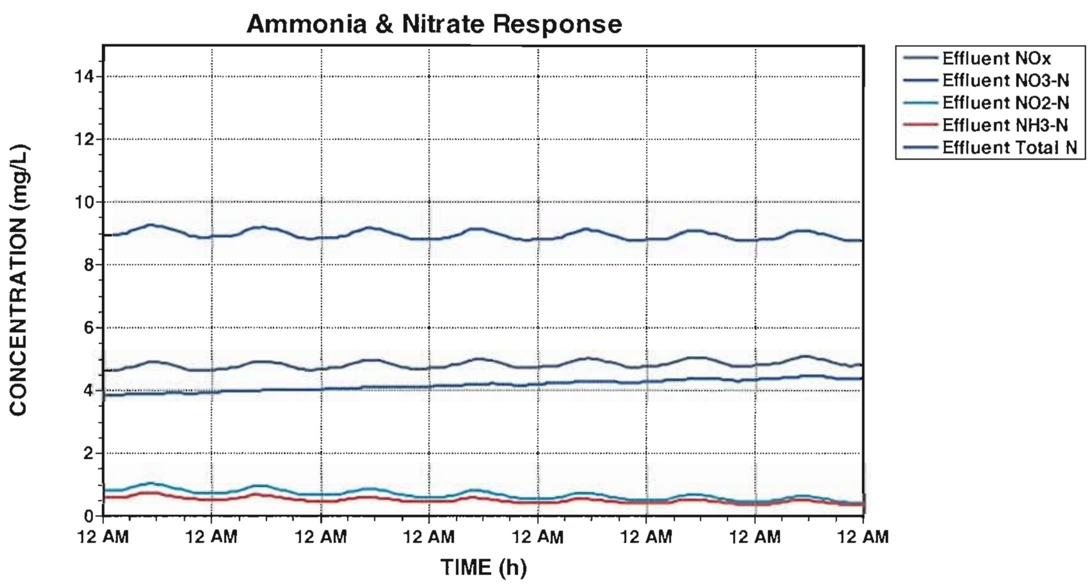
Album page - Volume Dist



Album page - N Profile



Album page - Dynamic Chart



Album page - Page 8

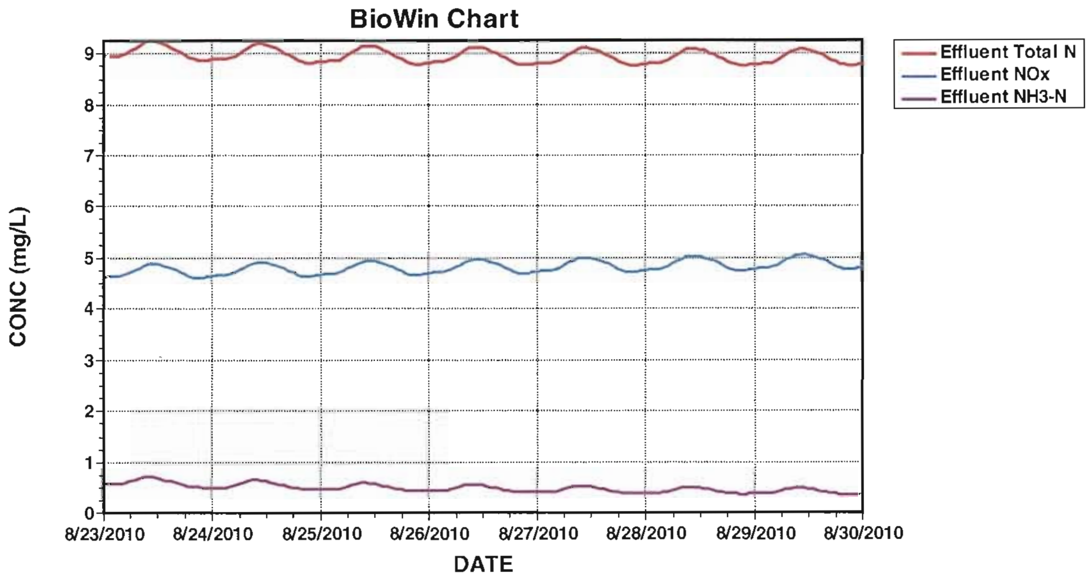
OX-AX Switch

Parameters	Conc. (mg/L)	Mass rate (lb/d)	Notes
Volatile suspended solids	2983.20	471542.05	
Total suspended solids	4345.11	686813.12	
Particulate COD	3727.63	589210.98	
Filtered COD	107.38	16972.83	
Total COD	3835.01	606183.81	
Soluble PO4-P	18.80	2972.19	
Total P	366.67	57958.07	
Filtered TKN	7.33	1158.11	

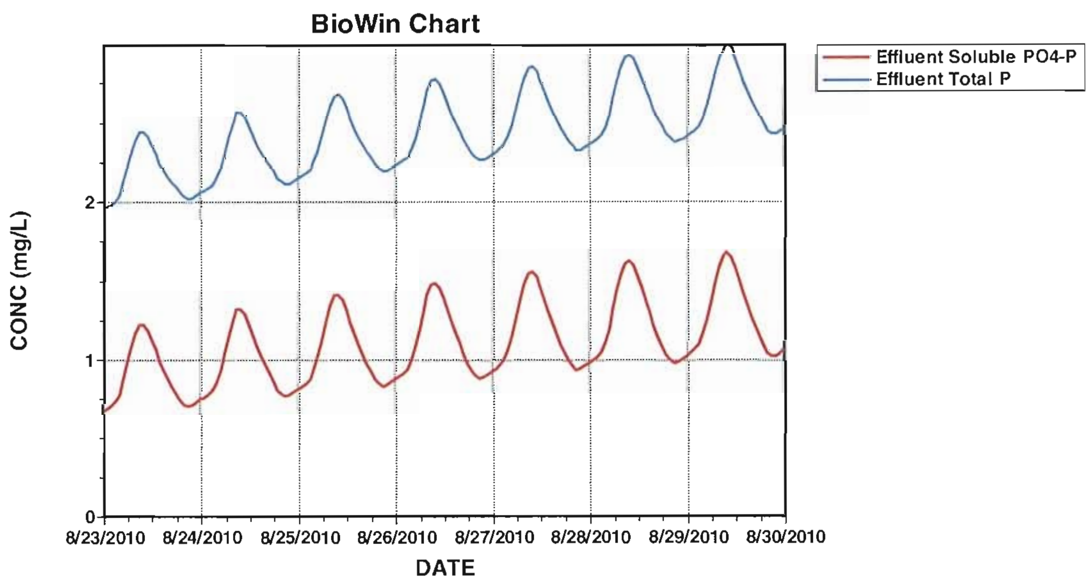
Particulate TKN	178.90	28277.92	
Total Kjeldahl Nitrogen	186.23	29436.04	
Filtered Carbonaceous BOD	2.47	390.61	
Total Carbonaceous BOD	1010.39	159707.58	
Nitrite + Nitrate	0.00	0.68	
Total N	186.23	29436.72	
Total inorganic N	5.96	942.33	
Alkalinity	4.26	305.41	mmol/L and kmol/d
pH	7.00		
Volatile fatty acids	1.40	221.06	
Total precipitated solids	0	0.00	
Total inorganic suspended solids	1361.91	215271.06	
Ammonia N	5.96	941.65	
Nitrate N	0.00	0.47	

Parameters	Value	Units
Hydraulic residence time	0.5	hours
Flow	18.94	mgd
MLSS	4345.11	mg/L
Total solids mass	15592.54	lb
Total readily biodegradable COD	3.48	mg/L
Total oxygen uptake rate	0.00	mgO/L/hr
Carbonaceous OUR	0.00	mgO/L/hr
Nitrogenous OUR	0.00	mgO/L/hr
Net. ammonia removal rate	-0.74	mgN/L/hr
Nitrate production rate	0.00	mgN/L/hr
Nitrite production rate	0.21	mgN/L/hr
Nitrate removal rate	0.21	mgN/L/hr
Nitrite removal rate	0.27	mgN/L/hr
Net. nitrate production rate	-0.21	mgN/L/hr
Net. nitrite production rate	-0.06	mgN/L/hr
Dissolved N2 gas production rate	0.27	mgN/L/hr
Spec. dissolved N2 gas production rate per VSS	0.09	mgN/gVSS/hr
Spec. dissolved N2 gas production per VASS	0.23	mgN/gVASS/hr
OTE	100.00	%
OTR	0	lb/hr
SOTE	100.00	%
SOTR	0	lb/hr
Air supply rate	0	ft3/min (20C, 1 atm)
Air flow rate / diffuser	0	ft3/min (20C, 1 atm)
# of diffusers	0	
Off gas flow rate (dry)	7.51	ft3/min
Oxygen content	0	%
Carbon dioxide content	41.25	%
Ammonia content	0.01	%
Actual DO sat. conc.	8.43	mg/L
Velocity gradient	82.88	1/s

Album page - EffTN



Album page - EffTP



Album page - ExportData

Elements Non-polyP heterotrophs [mgCOD/L] Anoxic methanol utilizers [mgCOD/L] Ammonia oxidizing biomass [mgCOD/L] Nitrite oxidizing biomass [mgCOD/L] Anaerobic ammonia oxidizers [mgCOD/L] PolyP heterotrophs [mgCOD/L] Propionic acetogens [mgCOD/L] Acetoclastic methanogens [mgCOD/L] Hydrogenotrophic methanogens [mgCOD/L] Endogenous products [mgCOD/L] Slowly bio. COD (part.) [mgCOD/L] Slowly bio. COD (colloid.) [mgCOD/L] Part. inert. COD [mgCOD/L] Part. bio. org. N [mgN/L] Part. bio. org. P [mgP/L] Part. inert N [mgN/L] Part. inert P [mgP/L] Stored PHA [mgCOD/L] Releasable stored polyP [mgP/L] Fixed stored polyP [mgP/L] PolyP bound cations [mg/L] Readily bio. COD (complex) [mgCOD/L] Acetate [mgCOD/L] Propionate [mgCOD/L] Methanol [mgCOD/L] Dissolved H2 [mgCOD/L] Dissolved methane [mg/L] Ammonia N [mgN/L] Sol. bio. org. N [mgN/L] Nitrite N [mgN/L] Nitrate N [mgN/L] Dissolved nitrogen gas [mgN/L] PO4-P (Sol. & Me

Complexed) [mgP/L] Sol. inert COD [mgCOD/L] Sol. inert TKN [mgN/L] Inorganic S.S. [mgISS/L]
Struvite [mgISS/L] Hydroxy-dicalcium-phosphate [mgISS/L] Hydroxy-apatite [mgISS/L] Magnesium [mg/L]
Calcium [mg/L] Metal [mg/L] Other Cations (strong bases) [meq/L] Other Anions (strong acids)
[meq/L] Total CO2 [mmol/L] User defined 1 [mg/L] User defined 2 [mg/L] User defined 3 [mgVSS/L]
User defined 4 [mgISS/L] Dissolved oxygen [mg/L] Flow [mgd] Liquid volume [Mil. Gal]
Temperature [deg. C] Volatile suspended solids [mgVSS/L] Total suspended solids [mgTSS/L]
Particulate COD [mg/L] Filtered COD [mg/L] Total COD [mg/L] Soluble PO4-P [mgP/L] Total P
[mgP/L] Filtered TKN [mgN/L] Particulate TKN [mgN/L] Total Kjeldahl Nitrogen [mgN/L] Filtered
Carbonaceous BOD [mg/L] Total Carbonaceous BOD [mg/L] Nitrite + Nitrate [mgN/L] Total N [mgN/L]
Total inorganic N [mgN/L] Alkalinity [mmol/L] pH [] Volatile fatty acids [mg/L] Total precipitated
solids [mgTSS/L] Total inorganic suspended solids [mgTSS/L]

Digester 1		2538.26	5.90	63.95	41.03	7.14	2702.74	4.43	393.35	306.41	5359.76
	7625.63	0.00	19921.76	234.44	63.36	199.22	219.14	1819.29	0.45	230.13	158.22
	0.10	179.63	0.56	0	0.02	36.54	449.16	0.23	0.00	0.00	0.07
	1576.33	249.59	12.05	5470.74	0	0	0	360.74	133.65	0	26.37
	11.93	58.82	0	0	0	0	0.00	0.04	0.37	35.00	33213.28
	40095.13	40789.65	429.90	41219.55	1576.33	2334.70	461.44	1226.66	1688.09	127.35	8544.97
	0.00	1688.09	449.16	32.89	7.00	180.19	0	6881.85			
Digester 2		621.83	4.04	28.78	18.47	5.53	1933.34	5.21	324.83	211.78	5870.57
	2415.81	0.00	19921.76	103.35	29.96	199.22	219.14	1301.96	0.00	164.62	113.44
	0.16	63.36	3.18	0	0.01	22.75	684.95	0.24	0.00	0.00	0.00
	1725.57	365.00	20.13	5470.74	0	0	0	376.27	137.92	0	29.01
	13.90	71.50	0	0	0	0	0.00	0.04	0.37	35.00	28342.38
	34874.27	32663.91	431.70	33095.61	1725.57	2334.70	705.32	931.89	1637.20	47.11	3791.41
	0.00	1637.20	684.95	47.50	7.00	66.53	0	6531.89			
OX-AX Switch		991.79	0.42	23.99	15.00	0.52	660.58	0.12	0.26	0.46	687.39
	53.45	0.02	1256.36	1.73	0.51	12.56	13.82	37.29	226.53	56.32	192.29
	2.08	0.34	1.06	0	12.27	0.08	5.96	0.38	0.00	0.00	18.10
	18.80	91.61	0.99	345.01	0	0	0	23.01	40.83	0	5.52
	5.01	6.11	0	0	0	0	0.00	18.94	0.43	20.00	2983.20
	4345.11	3727.63	107.38	3835.01	18.80	366.67	7.33	178.90	186.23	2.47	1010.39
	0.00	186.23	5.96	4.26	7.00	1.40	0	1361.91			
OX3	994.40	0.42	24.33	15.20	0.52	667.24	0.11	0.25	0.44	691.80	30.44
	0.00	1256.36	1.57	0.48	12.56	13.82	20.16	239.86	56.91	201.74	1.04
	0.00	0.00	0	0.24	0.01	0.92	0.60	0.18	3.20	15.67	4.60
	92.27	1.03	345.01	0	0	0	19.73	39.93	0	5.38	5.00
	5.66	0	0	0	0	1.00	18.94	0.43	20.00	2970.89	4376.54
	3701.67	93.54	3795.21	4.60	366.67	2.55	179.72	182.27	0.73	993.08	3.38
	185.65	4.30	3.67	7.00	0.00	0	1405.66				
OX1	994.89	0.42	24.14	15.07	0.52	663.38	0.12	0.26	0.45	688.86	43.08
	0.00	1256.36	1.69	0.50	12.56	13.82	30.89	231.68	56.57	195.95	1.48
	0.01	0.03	0	2.88	0.03	3.73	0.51	0.28	1.09	16.27	13.25
	91.83	1.00	345.01	0	0	0	21.74	40.48	0	5.47	5.01
	5.90	0	0	0	0	1.00	18.94	0.43	20.00	2979.22	4358.21
	3718.43	96.21	3814.65	13.25	366.67	5.24	179.38	184.62	1.07	1003.62	1.37
	186.00	5.10	4.01	7.00	0.03	0	1378.99				
OX2	995.44	0.42	24.27	15.14	0.52	665.59	0.11	0.25	0.45	690.33	35.64
	0.00	1256.36	1.63	0.49	12.56	13.82	25.08	236.17	56.76	199.14	1.19
	0.00	0.00	0	0.77	0.01	2.03	0.57	0.31	2.24	15.81	8.47
	92.05	1.02	345.01	0	0	0	20.64	40.17	0	5.42	5.00
	5.75	0	0	0	0	1.00	18.94	0.43	20.00	2974.97	4368.68
	3709.60	94.02	3803.62	8.47	366.67	3.62	179.63	183.25	0.85	998.11	2.55
	185.80	4.58	3.81	7.00	0.00	0	1393.71				
OX4	992.26	0.42	24.33	15.21	0.52	668.34	0.11	0.25	0.44	693.26	26.90
	0.00	1256.36	1.51	0.46	12.56	13.82	16.12	242.69	57.00	203.73	0.93
	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63	1.69
	92.49	1.05	345.01	0	0	0	19.04	39.74	0	5.35	5.00
	5.62	0	0	0	0	0.80	18.94	0.43	20.00	2966.97	4381.65
	3694.51	93.50	3788.02	1.69	366.67	2.03	179.70	181.74	0.66	988.42	3.78
	185.52	4.17	3.60	7.00	0.00	0	1414.67				
AX1	995.75	0.42	24.03	15.03	0.52	661.15	0.12	0.26	0.45	686.69	60.15
	0.66	1256.36	1.75	0.50	12.56	13.82	24.71	234.29	56.37	197.59	13.22
	0.40	0.49	0	5.03	0.05	5.55	0.51	0.04	0.12	18.35	10.92
	91.52	0.98	345.01	0	0	0	21.17	40.32	0	5.44	5.01
	6.17	0	0	0	0	0.00	18.94	0.43	20.00	2982.67	4368.86
	3725.63	111.32	3836.95	10.92	366.67	7.05	179.18	186.23	10.43	1017.82	0.15
	186.38	5.71	4.22	7.00	0.89	0	1386.19				
Effluent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63	1.69

	92.49	1.05	0.00	0	0	0	19.04	39.74	0	5.35	5.00
	5.62	0	0	0	0	0.80	2.58	0	20.00	0.01	0.02
	0.01	93.50	93.52	1.69	1.69	2.03	0.00	2.03	0.66	0.66	3.78
	5.82	4.17	3.60	7.00	0.00	0	0.01				
MLR	992.26	0.42	24.33	15.21	0.52	668.34	0.11	0.25	0.44	693.26	26.90
	0.00	1256.36	1.51	0.46	12.56	13.82	16.12	242.69	57.00	203.73	0.93
	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63	1.69
	92.49	1.05	345.01	0	0	0	19.04	39.74	0	5.35	5.00
	5.62	0	0	0	0	0.80	14.21	0	20.00	2966.97	4381.65
	3694.51	93.50	3788.02	1.69	366.67	2.03	179.70	181.74	0.66	988.42	3.78
	185.52	4.17	3.60	7.00	0.00	0	1414.67				
secondary clarifier underflow			2310.65	0.97	56.65	35.43	1.21	1556.33	0.26	0.58	1.01
	1614.37	62.65	0.00	2925.65	3.53	1.08	29.26	32.18	37.53	565.15	132.74
	474.41	0.93	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71
	15.63	1.69	92.49	1.05	803.42	0	0	0	19.04	39.74	0
	5.35	5.00	5.62	0	0	0	0	0.80	2.03	0	20.00
	6909.09	10203.40	8603.29	93.50	8696.79	1.69	851.61	2.03	418.47	420.50	0.66
	2300.82	3.78	424.28	4.17	3.60	7.00	0.00	0	3294.30		
primary sludge		11072.08	10.92	26.31	20.40	11.07	509.22	10.81	28.55	22.41	730.90
	33022.28	129.81	22749.01	249.87	13.85	227.49	250.24	81.38	143.38	42.52	126.53
	231.69	41.63	0.04	0	0.01	0.27	37.13	2.93	0.01	0.26	15.78
	26.33	85.28	0.55	6247.14	0	0	0	24.21	41.16	0	5.67
	5.11	7.68	0	0	0	0	0.06	0.02	0	20.00	49902.38
	57484.16	68295.35	488.45	68783.80	26.33	738.39	40.60	1326.03	1366.62	284.77	24344.40
	0.27	1366.89	37.39	6.23	7.00	41.67	0	7581.78			
recycles	87.76	0.07	2.26	1.42	0.09	71.02	0.05	2.58	1.70	104.08	21.25
	0.00	261.64	0.94	0.27	2.62	2.88	11.59	20.27	6.06	17.91	0.82
	9.14	0.46	0	0.08	3.28	99.12	0.55	0.07	3.17	13.38	250.33
	131.79	3.80	71.85	0.00	0.00	0.00	70.57	53.90	0	8.76	6.28
	15.12	0	0	0.00	0.00	0.68	0.23	0	20.00	470.75	640.27
	565.50	142.28	707.78	250.33	285.60	103.47	22.34	125.81	7.35	119.30	3.24
	129.05	102.36	9.78	7.00	9.60	0.00	169.53				
filter backwash		72.86	0.03	1.79	1.12	0.04	49.07	0.01	0.02	0.03	50.90
	1.98	0.00	92.25	0.11	0.03	0.92	1.01	1.18	17.82	4.19	14.96
	0.93	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63
	1.69	92.49	1.05	25.33	0.00	0.00	0.00	19.04	39.74	0	5.35
	5.00	5.62	0	0	0.00	0.00	0.80	0.13	0	20.00	217.85
	321.73	271.28	93.50	364.78	1.69	28.49	2.03	13.19	15.23	0.66	73.18
	3.78	19.01	4.17	3.60	7.00	0.00	0.00	103.87			
digester feed		11677.90	8.60	142.10	91.18	9.21	3778.04	6.94	18.08	15.45	4038.17
	19566.40	76.36	19921.76	154.88	10.55	199.22	219.14	131.76	1347.48	321.70	1134.76
	136.68	24.49	0.02	0	0.04	0.16	22.00	1.97	0.03	1.68	15.72
	16.18	88.25	0.75	5470.74	0	0	0	22.08	40.57	0	5.54
	5.06	6.83	0	0	0	0	0.36	0.04	0	20.00	44798.76
	56621.90	59405.60	325.85	59731.45	16.18	2334.70	24.72	1715.37	1740.09	167.79	19462.60
	1.72	1741.81	23.71	5.14	7.00	24.52	0.00	11823.14			
Thickened WAS		12543.51	5.28	307.54	192.32	6.56	8448.66	1.42	3.13	5.51	8763.73
	340.09	0.00	15882.08	19.15	5.84	158.82	174.70	203.74	3067.95	720.59	2575.36
	0.93	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63
	1.69	92.49	1.05	4361.40	0.00	0.00	0.00	19.04	39.74	0	5.35
	5.00	5.62	0	0	0.00	0.00	0.80	0.02	0	20.00	37506.50
	55389.86	46703.57	93.50	46797.07	1.69	4615.57	2.03	2271.68	2273.71	0.66	12487.28
	3.78	2277.50	4.17	3.60	7.00	0.00	0.00	17883.36			
WAS	2310.65	0.97	56.65	35.43	1.21	1556.33	0.26	0.58	1.01	1614.37	62.65
	0.00	2925.65	3.53	1.08	29.26	32.18	37.53	565.15	132.74	474.41	0.93
	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63	1.69
	92.49	1.05	803.42	0	0	0	19.04	39.74	0	5.35	5.00
	5.62	0	0	0	0	0.80	0.09	0	20.00	6909.09	10203.40
	8603.29	93.50	8696.79	1.69	851.61	2.03	418.47	420.50	0.66	2300.82	3.78
	424.28	4.17	3.60	7.00	0.00	0	3294.30				
AX1 feed	988.01	0.42	24.07	15.06	0.52	661.19	0.12	0.26	0.44	685.98	46.95
	19.14	1256.36	1.65	0.47	12.56	13.82	15.99	240.07	56.39	201.53	34.95
	6.14	0.01	0	0.08	0.04	5.80	0.94	0.07	3.20	15.65	5.32
	91.42	0.98	345.01	0	0	0	19.81	39.95	0	5.40	5.02
	5.92	0	0	0	0	0.69	18.94	0	20.00	2964.62	4368.18
	3695.37	151.73	3847.11	5.32	366.67	7.72	178.52	186.23	42.54	1034.11	3.27
	189.50	9.07	3.99	7.00	6.14	0	1403.56				
influent with recycles			131.16	0.13	0.31	0.24	0.13	6.03	0.13	0.34	0.27
	8.66	391.19	129.81	269.49	2.96	0.16	2.69	2.96	0.96	1.70	0.50
	1.50	231.69	41.63	0.04	0	0.01	0.27	37.13	2.93	0.01	0.26

15.78 26.33 85.28 0.55 74.00 0 0 0 24.21 41.16 0
5.67 5.11 7.68 0 0 0 0 0.06 2.81 0 20.00
591.15 680.97 809.04 488.45 1297.49 26.33 34.76 40.60 15.71 56.31 284.77
569.78 0.27 56.58 37.39 6.23 7.00 41.67 0 89.81

primary clarifiers 46.26 0.05 0.11 0.09 0.05 2.13 0.05 0.12 0.09 3.05
137.98 129.81 95.05 1.04 0.06 0.95 1.05 0.34 0.60 0.18 0.53
231.69 41.63 0.04 0 0.01 0.27 37.13 2.93 0.01 0.26 15.78
26.33 85.28 0.55 26.10 0 0 0 24.21 41.16 0 5.67
5.11 7.68 0 0 0 0 0.06 2.79 0.65 20.00 208.51
240.19 285.36 488.45 773.81 26.33 29.30 40.60 5.54 46.14 284.77 385.30
0.27 46.41 37.39 6.23 7.00 41.67 0 31.68

Thickening Centrifuge 140.04 0.06 3.43 2.15 0.07 94.32 0.02 0.03 0.06
97.84 3.80 0.00 177.31 0.21 0.07 1.77 1.95 2.27 34.25 8.04
28.75 0.93 0.00 0.00 0 0.09 0.00 0.38 0.60 0.08 3.71
15.63 1.69 92.49 1.05 48.69 0 0 0 19.04 39.74 0
5.35 5.00 5.62 0 0 0 0 0.80 0.07 0 20.00
418.73 618.39 521.41 93.50 614.91 1.69 53.20 2.03 25.36 27.40 0.66
140.06 3.78 31.18 4.17 3.60 7.00 0.00 0 199.65

belt press 33.92 0.22 1.57 1.01 0.30 105.45 0.28 17.72 11.55 320.20 131.77
0.00 1086.60 5.64 1.63 10.87 11.95 71.01 0.00 8.98 6.19 0.16
63.36 3.18 0 0.01 22.75 684.95 0.24 0.00 0.00 0.00 1725.57
365.00 20.13 298.39 0 0 0 376.27 137.92 0 29.01 13.90
71.50 0 0 0 0 0.00 0.03 0 20.00 1545.89 1902.16
1781.60 431.70 2213.30 1725.57 1758.80 705.32 50.83 756.15 47.11 251.33 0.00
756.15 684.95 47.18 7.00 66.53 0 356.27

filters 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.93
0.00 0.00 0 0.09 0.00 0.38 0.60 0.08 3.71 15.63 1.69
92.49 1.05 0.00 0 0 0 19.04 39.74 0 5.35 5.00
5.62 0 0 0 0 0.80 2.58 0 20.00 0.01 0.02
0.01 93.50 93.52 1.69 1.69 2.03 0.00 2.03 0.66 0.66 3.78
5.82 4.17 3.60 7.00 0.00 0 0.01

Dewatered Sludge 7091.72 46.12 328.21 210.60 63.10 22048.85 59.36 3704.55 2415.28 66951.22
27551.29 0.00 227198.97 1178.63 341.64 2271.99 2499.19 14848.29 0.00 1877.37
1293.74 0.16 63.36 3.18 0 0.01 22.75 684.95 0.24 0.00 0.00
0.00 1725.57 365.00 20.13 62391.43 0.00 0.00 0.00 376.27 137.92 0
29.01 13.90 71.50 0 0 0.00 0.00 0.00 0.00 0 20.00
323232.48 397725.79 372517.57 431.70 372949.27 1725.57 8672.34
705.32 10627.75 11333.07 47.11 42749.22 0.00 11333.07 684.95 47.18 7.00 66.53
0.00 74493.31

RAS 2310.65 0.97 56.65 35.43 1.21 1556.33 0.26 0.58 1.01 1614.37 62.65
0.00 2925.65 3.53 1.08 29.26 32.18 37.53 565.15 132.74 474.41 0.93
0.00 0.00 0 0.09 0.00 0.38 0.60 0.08 3.71 15.63 1.69
92.49 1.05 803.42 0 0 0 19.04 39.74 0 5.35 5.00
5.62 0 0 0 0 0.80 1.94 0 20.00 6909.09 10203.40
8603.29 93.50 8696.79 1.69 851.61 2.03 418.47 420.50 0.66 2300.82 3.78
424.28 4.17 3.60 7.00 0.00 0 3294.30

secondary clarifier feed 992.26 0.42 24.33 15.21 0.52 668.34 0.11 0.25 0.44
693.26 26.90 0.00 1256.36 1.51 0.46 12.56 13.82 16.12 242.69 57.00
203.73 0.93 0.00 0.00 0 0.09 0.00 0.38 0.60 0.08 3.71
15.63 1.69 92.49 1.05 345.01 0 0 0 19.04 39.74 0
5.35 5.00 5.62 0 0 0 0 0.80 4.74 0 20.00
2966.97 4381.65 3694.51 93.50 3788.02 1.69 366.67 2.03 179.70 181.74 0.66
988.42 3.78 185.52 4.17 3.60 7.00 0.00 0 1414.67

AX2 feed 995.75 0.42 24.03 15.03 0.52 661.15 0.12 0.26 0.45 686.69 60.15
0.66 1256.36 1.75 0.50 12.56 13.82 24.71 234.29 56.37 197.59 13.22
0.40 0.49 0 5.03 0.05 5.55 0.51 0.04 0.12 18.35 10.92
91.52 0.98 345.01 0 0 0 21.17 40.32 0 5.44 5.01
6.17 0 0 0 0 0.00 18.94 0 20.00 2982.67 4368.86
3725.63 111.32 3836.95 10.92 366.67 7.05 179.18 186.23 10.43 1017.82 0.15
186.38 5.71 4.22 7.00 0.89 0 1386.19

Inf 135.10 0.14 0.14 0.14 0.14 0.14 0.14 0.14 0.14 0 424.75
141.58 270.20 3.14 0.15 2.70 2.97 0 0.01 0 0.01 252.64
44.58 0 0 0 0 31.50 3.14 0 0 16.00 6.00
81.06 0.25 74.20 0 0 0 20.00 40.00 0 5.39 5.00
7.00 0 0 0 0 0 2.58 0 20.00 602.08 684.66
831.14 519.86 1351.00 6.00 12.00 34.89 15.11 50.00 309.94 610.66 0
50.00 31.50 5.90 7.00 44.58 0 82.58

influent 135.10 0.14 0.14 0.14 0.14 0.14 0.14 0.14 0.14 0 424.75
141.58 270.20 3.14 0.15 2.70 2.97 0 0.01 0 0.01 252.64

44.58	0	0	0	0	31.50	3.14	0	0	16.00	6.00
81.06	0.25	74.20	0	0	0	20.00	40.00	0	5.39	5.00
7.00	0	0	0	0	0	2.58	0	20.00	602.08	684.66
831.14	519.86	1351.00	6.00	12.00	34.89	15.11	50.00	309.94	610.66	0
50.00	31.50	5.90	7.00	44.58	0	82.58				
Secondary Clarifier	3.47	0.00	0.09	0.05	0.00	2.34	0.00	0.00	0.00	2.43
0.09	0.00	4.40	0.01	0.00	0.04	0.05	0.06	0.85	0.20	0.71
0.93	0.00	0.00	0	0.09	0.00	0.38	0.60	0.08	3.71	15.63
1.69	92.49	1.05	1.21	0	0	0	19.04	39.74	0	5.35
5.00	5.62	0	0	0	0	0.80	2.71	5.27	20.00	10.38
15.34	12.93	93.50	106.43	1.69	2.96	2.03	0.63	2.66	0.66	4.11
3.78	6.45	4.17	3.60	7.00	0.00	0	4.95			

Global Parameters

AOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.90000	0.70000	1.0720
Substrate (NH4) half sat. [mgN/L]	0.70000	1.00000	1.0000
Aerobic decay rate [1/d]	0.17000	0.17000	1.0290
Anoxic/anaerobic decay rate [1/d]	0.08000	0.08000	1.0290
KiHNO2 [mmol/L]	0.00500	0.00500	1.0000

NOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.70000	0.70000	1.0600
Substrate (NO2) half sat. [mgN/L]	0.10000	0.10000	1.0000
Aerobic decay rate [1/d]	0.17000	0.17000	1.0290
Anoxic/anaerobic decay rate [1/d]	0.08000	0.08000	1.0290
KiNH3 [mmol/L]	0.07500	0.07500	1.0000

ANAMMOX

Name	Default	Value	
Max. spec. growth rate [1/d]	0.10000	0.10000	1.1000
Substrate (NH4) half sat. [mgN/L]	2.00000	2.00000	1.0000
Substrate (NO2) half sat. [mgN/L]	1.00000	1.00000	1.0000
Aerobic decay rate [1/d]	0.01900	0.01900	1.0290
Anoxic/anaerobic decay rate [1/d]	0.00950	0.00950	1.0290
Ki Nitrite [mgN/L]	1000.00000	1000.00000	1.0000
Nitrite sensitivity constant [L / (d mgN)]	0.01600	0.01600	1.0000

OHOs

Name	Default	Value	
Max. spec. growth rate [1/d]	3.20000	3.20000	1.0290
Substrate half sat. [mgCOD/L]	5.00000	5.00000	1.0000
Anoxic growth factor [-]	0.50000	0.50000	1.0000
Aerobic decay [1/d]	0.62000	0.62000	1.0290
Anoxic/anaerobic decay [1/d]	0.30000	0.30000	1.0290
Hydrolysis rate (AS) [1/d]	2.10000	2.10000	1.0290
Hydrolysis half sat. (AS) [-]	0.06000	0.06000	1.0000
Anoxic hydrolysis factor [-]	0.28000	0.28000	1.0000
Anaerobic hydrolysis factor [-]	0.50000	0.50000	1.0000
Adsorption rate of colloids [L/(mgCOD d)]	0.80000	0.80000	1.0290

Ammonification rate [L/(mgN d)]	0.04000	0.04000	1.0290
Assimilative nitrate/nitrite reduction rate [1/d]	0.50000	0.50000	1.0000
Fermentation rate [1/d]	3.20000	3.20000	1.0290
Fermentation half sat. [mgCOD/L]	5.00000	5.00000	1.0000
Anaerobic growth factor (AS) [-]	0.12500	0.12500	1.0000
Hydrolysis rate (AD) [1/d]	0.10000	0.10000	1.0500
Hydrolysis half sat. (AD) [mgCOD/L]	0.15000	0.15000	1.0000

Methylotrophs

Name	Default	Value	
Max. spec. growth rate of methanol utilizers [1/d]	1.30000	1.30000	1.0720
Methanol half sat. [mgCOD/L]	0.50000	0.50000	1.0000
Aerobic decay rate of methanol utilizers [1/d]	0.04000	0.04000	1.0290
Anoxic/anaerobic decay rate of methanol utilizers [1/d]	0.03000	0.03000	1.0290

PAOs

Name	Default	Value	
Max. spec. growth rate [1/d]	0.95000	0.95000	1.0000
Max. spec. growth rate, P-limited [1/d]	0.42000	0.42000	1.0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0.10000	0.10000	1.0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0.05000	0.05000	1.0000
Magnesium half sat. [mgMg/L]	0.10000	0.10000	1.0000
Cation half sat. [mmol/L]	0.10000	0.10000	1.0000
Calcium half sat. [mgCa/L]	0.10000	0.10000	1.0000
Aerobic decay rate [1/d]	0.10000	0.10000	1.0000
Anaerobic decay rate [1/d]	0.04000	0.04000	1.0000
Sequestration rate [1/d]	6.00000	6.00000	1.0000
Anoxic growth factor NO3 [-]	0.33000	0.33000	1.0000
Anoxic growth factor NO2 [-]	0.33000	0.33000	1.0000

Acetogens

Name	Default	Value	
Max. spec. growth rate [1/d]	0.25000	0.25000	1.0290
Substrate half sat. [mgCOD/L]	10.00000	10.00000	1.0000
Acetate inhibition [mgCOD/L]	10000.00000	10000.00000	1.0000
Decay rate [1/d]	0.05000	0.05000	1.0290
Aerobic decay rate [1/d]	0.52000	0.52000	1.0290

Methanogens

Name	Default	Value	
Acetoclastic Mu Max [1/d]	0.30000	0.30000	1.0290
H2-utilizing Mu Max [1/d]	1.40000	1.40000	1.0290
Acetoclastic Ks [mgCOD/L]	100.00000	100.00000	1.0000
Acetoclastic methanol Ks [mgCOD/L]	0.50000	0.50000	1.0000
H2-utilizing CO2 half sat. [mmol/L]	0.10000	0.10000	1.0000
H2-utilizing Ks [mgCOD/L]	0.10000	0.10000	1.0000
H2-utilizing methanol Ks [mgCOD/L]	0.50000	0.50000	1.0000
Acetoclastic propionic inhibition [mgCOD/L]	10000.00000	10000.00000	1.0000
Acetoclastic decay rate [1/d]	0.13000	0.13000	1.0290
Acetoclastic aerobic decay rate [1/d]	0.60000	0.60000	1.0290
H2-utilizing decay rate [1/d]	0.13000	0.13000	1.0290
H2-utilizing aerobic decay rate [1/d]	0.60000	0.60000	1.0290

pH

Name	Default	Value
Heterotrophs low pH limit [-]	4.00000	4.00000
Heterotrophs high pH limit [-]	10.00000	10.00000
Methanol utilizers low pH limit [-]	4.00000	4.00000
Methanol utilizers high pH limit [-]	10.00000	10.00000
Autotrophs low pH limit [-]	5.50000	5.50000
Autotrophs high pH limit [-]	9.50000	9.50000
PolyP heterotrophs low pH limit [-]	4.00000	4.00000
Poly P heterotrophs high pH limit [-]	10.00000	10.00000
Heterotrophs low pH limit (anaerobic) [-]	5.50000	5.50000
Heterotrophs high pH limit (anaerobic) [-]	8.50000	8.50000
Propionic acetogens low pH limit [-]	4.00000	4.00000
Propionic acetogens high pH limit [-]	10.00000	10.00000
Acetoclastic methanogens low pH limit [-]	5.00000	5.00000
Acetoclastic methanogens high pH limit [-]	9.00000	9.00000
H2-utilizing methanogens low pH limit [-]	5.00000	5.00000
H2-utilizing methanogens high pH limit [-]	9.00000	9.00000

Switches

Name	Default	Value
Heterotrophic DO half sat. [mgO2/L]	0.05000	0.05000
Aerobic denit. DO half sat. [mgO2/L]	0.05000	0.20000
Ammonia oxidizer DO half sat. [mgO2/L]	0.25000	0.25000
Nitrite oxidizer DO half sat. [mgO2/L]	0.50000	0.50000
Anaerobic ammonia oxidizer DO half sat. [mgO2/L]	0.01000	0.01000
Anoxic NO3 half sat. [mgN/L]	0.10000	0.10000
Anoxic NO2 half sat. (mgN/L)	0.01000	0.05000
NH3 nutrient half sat. [mgN/L]	1.0000E-4	1.0000E-4
PolyP half sat. [mgP/L]	0.01000	0.01000
VFA sequestration half sat. [mgCOD/L]	5.00000	5.00000
P uptake half sat. [mgP/L]	0.15000	0.10000
P nutrient half sat. [mgP/L]	0.00100	0.00100
Autotroph CO2 half sat. [mmol/L]	0.10000	0.01000
Heterotrophic Hydrogen half sat. [mgCOD/L]	1.00000	1.00000
Propionic acetogens Hydrogen half sat. [mgCOD/L]	5.00000	5.00000
Synthesis anion/cation half sat. [meq/L]	0.01000	0.01000

Common

Name	Default	Value
N in endogenous residue [mgN/mgCOD]	0.07000	0.07000
P in endogenous residue [mgP/mgCOD]	0.02200	0.02200
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1.60000	1.80000
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1.60000	1.00000

AOB

Name	Default	Value
Yield [mgCOD/mgN]	0.15000	0.15000
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

NOB

Name	Default	Value
Yield [mgCOD/mgN]	0.09000	0.09000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

ANAMMOX

Name	Default	Value
Yield [mgCOD/mgN]	0.11400	0.11400
Nitrate production [mgN/mgBiomassCOD]	2.28000	2.28000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

OHOs

Name	Default	Value
Yield (aerobic) [-]	0.66600	0.66600
Yield (fermentation, low H2) [-]	0.10000	0.10000
Yield (fermentation, high H2) [-]	0.10000	0.10000
H2 yield (fermentation low H2) [-]	0.35000	0.35000
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0.70000	0.70000
CO2 yield (fermentation, low H2) [-]	0.70000	0.70000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Yield (anoxic) [-]	0.54000	0.66600
Yield propionic (aerobic) [-]	0.64000	0.50000
Yield propionic (anoxic) [-]	0.46000	0.41000
Yield acetic (aerobic) [-]	0.60000	0.40000
Yield acetic (anoxic) [-]	0.43000	0.32000
Yield methanol (aerobic) [-]	0.50000	0.50000
Adsorp. max. [-]	1.00000	1.00000

Methylotrophs

Name	Default	Value
Yield (anoxic) [-]	0.40000	0.40000
N in biomass [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02200
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

PAOs

Name	Default	Value
Yield (aerobic) [-]	0.63900	0.63900
Yield (anoxic) [-]	0.52000	0.54000
Aerobic P/PHA uptake [mgP/mgCOD]	0.95000	0.95000
Anoxic P/PHA uptake [mgP/mgCOD]	0.35000	0.35000
Yield of PHA on sequestration [-]	0.88900	0.88900
N in biomass [mgN/mgCOD]	0.07000	0.07000
N in sol. inert [mgN/mgCOD]	0.07000	0.07000
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous part. [-]	0.25000	0.25000
Inert fraction of endogenous sol. [-]	0.20000	0.20000
P/Ac release ratio [mgP/mgCOD]	0.49000	0.49000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
Yield of low PP [-]	0.94000	0.94000

Acetogens

Name	Default	Value
Yield [-]	0.10000	0.10000
H2 yield [-]	0.40000	0.40000
CO2 yield [-]	1.00000	1.00000
N in biomass [mgN/mgCOD]	0.07000	0.06800
P in biomass [mgP/mgCOD]	0.02200	0.02100
Fraction to endogenous residue [-]	0.08000	0.08000
COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

Methanogens

Name	Default	Value
Acetoclastic yield [-]	0.10000	0.10000
Methanol acetoclastic yield [-]	0.10000	0.10000
H2-utilizing yield [-]	0.10000	0.10000
Methanol H2-utilizing yield [-]	0.10000	0.10000
N in acetoclastic biomass [mgN/mgCOD]	0.07000	0.06800
N in H2-utilizing biomass [mgN/mgCOD]	0.07000	0.06800
P in acetoclastic biomass [mgP/mgCOD]	0.02200	0.02100
P in H2-utilizing biomass [mgP/mgCOD]	0.02200	0.02100
Acetoclastic fraction to endog. residue [-]	0.08000	0.08000
H2-utilizing fraction to endog. residue [-]	0.08000	0.08000
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1.42000	1.42000

General

Name	Default	Value
Ash content of biomass (synthesis ISS) [%]	8.00000	8.00000
Molecular weight of other anions [mg/mmol]	35.50000	35.50000
Molecular weight of other cations [mg/mmol]	39.10000	39.10000
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0.30000	0.30000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0.30000	0.30000
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0.05000	0.05000
Cation to P mole ratio in organic phosphate [meq/mmolP]	0.01000	0.01000
Bubble rise velocity (anaerobic digester) [cm/s]	23.90000	23.90000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0.35000	0.35000
Anaerobic digester gas hold-up factor []	1.00000	1.00000
Tank head loss per metre of length (from flow) [m/m]	0.00250	0.00250

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17.00000	17.28000	1.0240
Kl for CO2 [m/d]	10.00000	10.00000	1.0240
Kl for NH3 [m/d]	1.00000	1.00000	1.0240
Kl for CH4 [m/d]	8.00000	8.00000	1.0240
Kl for N2 [m/d]	15.00000	15.00000	1.0240
Kl for O2 [m/d]	13.00000	13.00000	1.0240

Physico-chemical rates

Name	Default	Value	
Struvite precipitation rate [1/d]	3.0000E+10	3.0000E+10	1.0240
Struvite redissolution rate [1/d]	3.0000E+11	3.0000E+11	1.0240
Struvite half sat. [mgTSS/L]	1.00000	1.00000	1.0000
HDP precipitation rate [L/(molP d)]	1.0000E+8	1.0000E+8	1.0000
HDP redissolution rate [L/(mol P d)]	1.0000E+8	1.0000E+8	1.0000
HAP precipitation rate [molHDP/(L d)]	5.0000E-4	5.0000E-4	1.0000

Physico-chemical constants

Name	Default	Value
Struvite solubility constant [mol/L]	6.9180E-14	6.9180E-14
HDP solubility product [mol/L]	2.7500E-22	2.7500E-22
HDP half sat. [mgTSS/L]	1.00000	1.00000
Equilibrium soluble PO4 with Al dosing at pH 7 [mgP/L]	0.01000	0.01000
Al to P ratio [molAl/molP]	0.80000	0.80000
Al(OH)3 solubility product [mol/L]	1.2590E+9	1.2590E+9
AlHPO4+ dissociation constant [mol/L]	7.9430E-13	7.9430E-13
Equilibrium soluble PO4 with Fe dosing at pH 7 [mgP/L]	0.01000	0.01000
Fe to P ratio [molFe/molP]	1.60000	1.60000
Fe(OH)3 solubility product [mol/L]	0.05000	0.05000
FeH2PO4++ dissociation constant [mol/L]	5.0120E-22	5.0120E-22

Aeration

Name	Default	Value
Alpha (surf) OR Alpha F (diff) [-]	0.50000	0.50000
Beta [-]	0.95000	0.95000
Surface pressure [kPa]	101.32500	101.32500
Fractional effective saturation depth (Fed) [-]	0.32500	0.32500
Supply gas CO2 content [vol. %]	0.03500	0.03500
Supply gas O2 [vol. %]	20.95000	20.95000
Off-gas CO2 [vol. %]	2.00000	2.00000
Off-gas O2 [vol. %]	18.80000	18.80000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Surface turbulence factor [-]	2.00000	2.00000
Set point controller gain []	1.00000	1.00000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.3873	0.3873
Vesilind hindered zone settling parameter (K) [L/g]	0.3700	0.3700
Clarification switching function [mg/L]	100.0000	20.0000
Specified TSS conc.for height calc. [mg/L]	2500.0000	2500.0000
Maximum compactability constant [mg/L]	15000.0000	15000.0000

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.9341	0.9341
Maximum (practical) settling velocity (Vo') [ft/min]	0.6152	0.6152
Hindered zone settling parameter (Kh) [L/g]	0.4000	0.4000
Flocculent zone settling parameter (Kf) [L/g]	2.5000	2.5000
Maximum non-settleable TSS [mg/L]	20.0000	20.0000
Non-settleable fraction [-]	0.0010	0.0010
Specified TSS conc. for height calc. [mg/L]	2500.0000	2500.0000

Biofilm general

Name	Default	Value	
Attachment rate [g / (m2 d)]	80.00000	80.00000	1.0000
Attachment TSS half sat. [mg/L]	100.00000	100.00000	1.0000
Detachment rate [g/(m3 d)]	8.0000E+4	8.0000E+4	1.0000
Solids movement factor []	10.00000	10.00000	1.0000
Diffusion neta []	0.80000	0.80000	1.0000
Thin film limit [mm]	0.50000	0.50000	1.0000
Thick film limit [mm]	3.00000	3.00000	1.0000
Assumed Film thickness for tank volume correction (temp independant) [mm]	0.75000	0.75000	1.0000
Film surface area to media area ratio - Max.[ ]	1.00000	1.00000	1.0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4.00000	4.00000	1.0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Non-polyP heterotrophs	5.0000E+4	5.0000E+4	1.0000
Anoxic methanol utilizers	5.0000E+4	5.0000E+4	1.0000
Ammonia oxidizing biomass	1.0000E+5	1.0000E+5	1.0000
Nitrite oxidizing biomass	1.0000E+5	1.0000E+5	1.0000
Anaerobic ammonia oxidizers	5.0000E+4	5.0000E+4	1.0000
PolyP heterotrophs	5.0000E+4	5.0000E+4	1.0000
Propionic acetogens	5.0000E+4	5.0000E+4	1.0000
Acetoclastic methanogens	5.0000E+4	5.0000E+4	1.0000
Hydrogenotrophic methanogens	5.0000E+4	5.0000E+4	1.0000
Endogenous products	3.0000E+4	3.0000E+4	1.0000
Slowly bio. COD (part.)	5000.00000	5000.00000	1.0000
Slowly bio. COD (colloid.)	0	0	1.0000
Part. inert. COD	5000.00000	5000.00000	1.0000
Part. bio. org. N	0	0	1.0000
Part. bio. org. P	0	0	1.0000
Part. inert N	0	0	1.0000
Part. inert P	0	0	1.0000
Stored PHA	5000.00000	5000.00000	1.0000
Releasable stored polyP	1.1500E+6	1.1500E+6	1.0000
Fixed stored polyP	1.1500E+6	1.1500E+6	1.0000
PolyP bound cations	1.1500E+6	1.1500E+6	1.0000

Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.0000E+10	1.0000E+10	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
Inorganic S.S.	1.3000E+6	1.3000E+6	1.0000
Struvite	8.5000E+5	8.5000E+5	1.0000
Hydroxy-dicalcium-phosphate	1.1500E+6	1.1500E+6	1.0000
Hydroxy-apatite	1.6000E+6	1.6000E+6	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.0000E+10	1.0000E+10	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	5.0000E+4	5.0000E+4	1.0000
User defined 4	5.0000E+4	5.0000E+4	1.0000
Dissolved oxygen	0	0	1.0000

Effective diffusivities [m2/s]

Name	Default	Value	
Non-polyP heterotrophs	5.0000E-14	5.0000E-14	1.0290
Anoxic methanol utilizers	5.0000E-14	5.0000E-14	1.0290
Ammonia oxidizing biomass	5.0000E-14	5.0000E-14	1.0290
Nitrite oxidizing biomass	5.0000E-14	5.0000E-14	1.0290
Anaerobic ammonia oxidizers	5.0000E-14	5.0000E-14	1.0290
PolyP heterotrophs	5.0000E-14	5.0000E-14	1.0290
Propionic acetogens	5.0000E-14	5.0000E-14	1.0290
Acetoclastic methanogens	5.0000E-14	5.0000E-14	1.0290
Hydrogenotrophic methanogens	5.0000E-14	5.0000E-14	1.0290
Endogenous products	5.0000E-14	5.0000E-14	1.0290
Slowly bio. COD (part.)	5.0000E-14	5.0000E-14	1.0290
Slowly bio. COD (colloid.)	6.9000E-11	6.9000E-11	1.0290
Part. inert. COD	5.0000E-14	5.0000E-14	1.0290
Part. bio. org. N	5.0000E-14	5.0000E-14	1.0290
Part. bio. org. P	5.0000E-14	5.0000E-14	1.0290
Part. inert N	5.0000E-14	5.0000E-14	1.0290
Part. inert P	5.0000E-14	5.0000E-14	1.0290
Stored PHA	5.0000E-14	5.0000E-14	1.0290
Releasable stored polyP	5.0000E-14	5.0000E-14	1.0290
Fixed stored polyP	5.0000E-14	5.0000E-14	1.0290
PolyP bound cations	5.0000E-14	5.0000E-14	1.0290
Readily bio. COD (complex)	6.9000E-10	6.9000E-10	1.0290
Acetate	1.2400E-9	1.2400E-9	1.0290
Propionate	8.3000E-10	8.3000E-10	1.0290
Methanol	1.6000E-9	1.6000E-9	1.0290
Dissolved H2	5.8500E-9	5.8500E-9	1.0290
Dissolved methane	1.9625E-9	1.9625E-9	1.0290
Ammonia N	2.0000E-9	2.0000E-9	1.0290
Sol. bio. org. N	1.3700E-9	1.3700E-9	1.0290
Nitrite N	2.9800E-9	2.9800E-9	1.0290
Nitrate N	2.9800E-9	2.9800E-9	1.0290
Dissolved nitrogen gas	1.9000E-9	1.9000E-9	1.0290
PO4-P (Sol. & Me Complexed)	2.0000E-9	2.0000E-9	1.0290

Sol. inert COD	6.9000E-10	6.9000E-10	1.0290
Sol. inert TKN	6.8500E-10	6.8500E-10	1.0290
Inorganic S.S.	5.0000E-14	5.0000E-14	1.0290
Struvite	5.0000E-14	5.0000E-14	1.0290
Hydroxy-dicalcium-phosphate	5.0000E-14	5.0000E-14	1.0290
Hydroxy-apatite	5.0000E-14	5.0000E-14	1.0290
Magnesium	7.2000E-10	7.2000E-10	1.0290
Calcium	7.2000E-10	7.2000E-10	1.0290
Metal	4.8000E-10	4.8000E-10	1.0290
Other Cations (strong bases)	1.4400E-9	1.4400E-9	1.0290
Other Anions (strong acids)	1.4400E-9	1.4400E-9	1.0290
Total CO2	1.9600E-9	1.9600E-9	1.0290
User defined 1	6.9000E-10	6.9000E-10	1.0290
User defined 2	6.9000E-10	6.9000E-10	1.0290
User defined 3	5.0000E-14	5.0000E-14	1.0290
User defined 4	5.0000E-14	5.0000E-14	1.0290
Dissolved oxygen	2.5000E-9	2.5000E-9	1.0290

EPS Strength coefficients [ ]

Name	Default	Value	
Non-polyP heterotrophs	1.00000	1.00000	1.0000
Anoxic methanol utilizers	1.00000	1.00000	1.0000
Ammonia oxidizing biomass	1.00000	1.00000	1.0000
Nitrite oxidizing biomass	1.00000	1.00000	1.0000
Anaerobic ammonia oxidizers	1.00000	1.00000	1.0000
PolyP heterotrophs	1.00000	1.00000	1.0000
Propionic acetogens	1.00000	1.00000	1.0000
Acetoclastic methanogens	1.00000	1.00000	1.0000
Hydrogenotrophic methanogens	1.00000	1.00000	1.0000
Endogenous products	1.00000	1.00000	1.0000
Slowly bio. COD (part.)	1.00000	1.00000	1.0000
Slowly bio. COD (colloid.)	0	0	1.0000
Part. inert. COD	1.00000	1.00000	1.0000
Part. bio. org. N	1.00000	1.00000	1.0000
Part. bio. org. P	1.00000	1.00000	1.0000
Part. inert N	1.00000	1.00000	1.0000
Part. inert P	1.00000	1.00000	1.0000
Stored PHA	1.00000	1.00000	1.0000
Releasable stored polyP	1.00000	1.00000	1.0000
Fixed stored polyP	1.00000	1.00000	1.0000
PolyP bound cations	1.00000	1.00000	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.00000	1.00000	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
Inorganic S.S.	0.33000	0.33000	1.0000
Struvite	1.00000	1.00000	1.0000
Hydroxy-dicalcium-phosphate	1.00000	1.00000	1.0000
Hydroxy-apatite	1.00000	1.00000	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.00000	1.00000	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000

User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	1.00000	1.00000	1.0000
User defined 4	1.00000	1.00000	1.0000
Dissolved oxygen	0	0	1.0000

Average Design Flow and Loads with one aeration train out of service.

BioWin user and configuration data

Project details

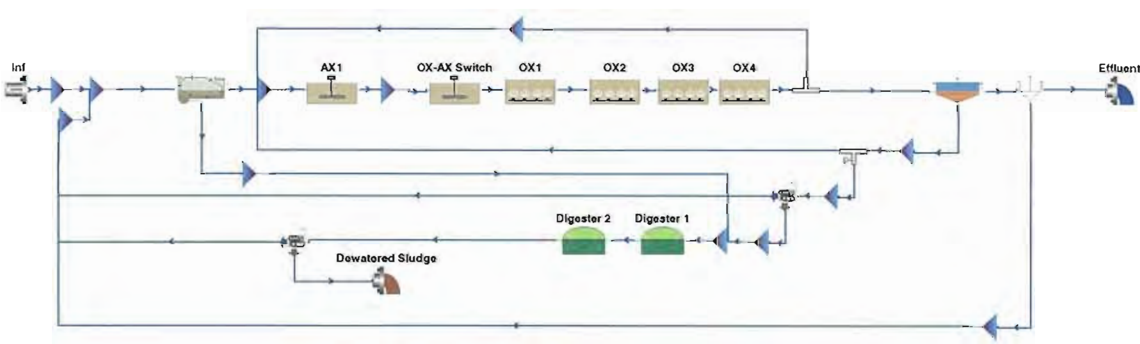
Project name: Current MM WInter **Project ref.: BW3**
Plant name: Sundog WWTP **User name: KNA**

Created: 5/31/2004 **Saved: 9/2/2010**

Steady state solution

Target SRT: 9.83333333333333 SRT: 9.83
Temperature: 20.0

Flowsheet



Configuration information for all Anaerobic Digester units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	Head space volume
Digester 1	0.3672	1963.5001	25.000	0.5
Digester 2	0.3672	1963.5001	25.000	0.5

Operating data Average (flow/time weighted as required)

Element name	Pressure [psi]	pH
Digester 1	14.9	7.0
Digester 2	14.9	7.0

Element name	Average Temperature
Digester 1	35.0
Digester 2	35.0

Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
OX-AX Switch	0.4300	5225.6947	11.000	Un-aerated
OX3	0.4300	5225.6947	11.000	1184
OX1	0.4300	5225.6947	11.000	1184
OX2	0.4300	5225.6947	11.000	1184
OX4	0.4300	5225.6947	11.000	1184
AX1	0.4300	5225.6947	11.000	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
OX-AX Switch	0
OX3	1.0
OX1	1.0
OX2	1.0
OX4	0.8
AX1	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
OX-AX Switch	2.5656	0.0432	0.8200	0.0410	10.0000
OX3	2.5656	0.0432	0.8200	0.0410	10.0000
OX1	2.5656	0.0432	0.8200	0.0410	10.0000
OX2	2.5656	0.0432	0.8200	0.0410	10.0000
OX4	2.5656	0.0432	0.8200	0.0410	10.0000
AX1	2.5656	0.0432	0.8200	0.0410	10.0000

Configuration information for all Effluent units

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Secondary Clarifier	5.2740	53819.5520	13.100

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Secondary Clarifier	Ratio	0.75

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Secondary Clarifier	Uses global setting	No	99.80	0.05

Configuration information for all COD Influent units

Operating data Average (flow/time weighted as required)

Element name	Inf
Time	0
Flow	5.16
Total COD mgCOD/L	776.00
Total Kjeldahl Nitrogen mgN/L	39.50
Total P mgP/L	10.00
Nitrate N mgN/L	0
pH	7.70
Alkalinity mmol/L	5.90
Inorganic S.S. mgISS/L	41.60
Calcium mg/L	40.00
Magnesium mg/L	20.00
Dissolved oxygen mg/L	0

Element name	Inf
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2200
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.7500
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0400
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.2000
Fna - Ammonia [gNH3-N/gTKN]	0.6300
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0050
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0100
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - Non-poly-P heterotrophs [gCOD/g of total COD]	0.1000
FZbm - Anoxic methanol utilizers [gCOD/g of total COD]	0.0001
FZaob - Ammonia oxidizers [gCOD/g of total COD]	0.0001
FZnob - Nitrite oxidizers [gCOD/g of total COD]	0.0001
FZamob - Anaerobic ammonia oxidizers [gCOD/g of total COD]	0.0001
FZbp - PAOs [gCOD/g of total COD]	0.0001
FZbpa - Propionic acetogens [gCOD/g of total COD]	0.0001
FZbam - Acetoclastic methanogens [gCOD/g of total COD]	0.0001
FZbhm - H2-utilizing methanogens [gCOD/g of total COD]	0.0001

Configuration information for all Ideal primary settling tank units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
primary clarifiers	0.6508	8700.0000	10.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
primary clarifiers	Fraction	0.01

Element name	Percent removal	Blanket fraction
primary clarifiers	65.00	0.10

Configuration information for all Dewatering unit units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Thickening Centrifuge	Fraction	0.18
belt press	Fraction	0.08

Element name	Percent removal
Thickening Centrifuge	95.00
belt press	95.00

Configuration information for all Point clarifier units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
filters	Ratio	0.05

Element name	Percent removal
filters	99.90

Configuration information for all Sludge units

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
RAS	Flowrate [Side]	0.0750863262780211
secondary clarifier feed	Ratio	3.00

BioWin Album

Album page - Air

Elements	Total oxygen uptake rate [mg O/L/hr]	Carbonaceous OUR [mg O/L/hr]	Nitrogenous OUR [mg O/L/hr]	Net. nitrite production rate [mg N/L/hr]	Dissolved N2 gas production rate [mg N/L/hr]	Spec. dissolved N2 gas production rate per VSS [mg N/g VSS/hr]	Spec. dissolved N2 gas production per VASS [mg N/g VASS/hr]	OTE [%]	OTR [lb/hr]	SOTE [%]	Off gas flow rate (dry) [ft3/min]	Ammonia N [mg N/L]	Nitrate N [mg N/L]	Air supply rate [ft3/min (20 C, 1 atm)]	Air flow rate / diffuser [ft3/min (20 C, 1 atm)]	# of diffusers []
AX1	2.53	2.38	0.16	0.09	9.05	2.42	6.49	100.00	0	100.00	4.04	4.26	0.38	0	0	0
OX-AX Switch	0.01	0.01	0.00	-0.31	1.66	0.45	1.20	100.00	0	100.00	5.22	4.63	0.01	0	0	0
OX1	43.90	23.23	20.67	0.87	0.57	0.15	0.41	8.19	170.70	22.31	2020.21	3.01	0.98	1996.04	1.69	1184.00
OX2	37.75	19.45	18.30	0.07	0.46	0.12	0.33	8.60	135.46	23.42	1514.75	1.74	1.99	1508.86	1.27	1184.00
OX3	32.10	18.20	13.90	-0.38	0.39	0.10	0.28	8.91	115.19	24.27	1238.94	0.86	2.83	1238.21	1.05	1184.00
OX4	25.36	16.98	8.38	-0.30	0.35	0.09	0.25	9.78	88.37	25.93	865.23	0.40	3.31	865.80	0.73	1184.00

Album page - Volume

Elements	Liquid volume [Mil. Gal]
AX1	0.43
OX-AX Switch	0.43
OX1	0.43
OX2	0.43
OX3	0.43
OX4	0.43

Album page - Tables

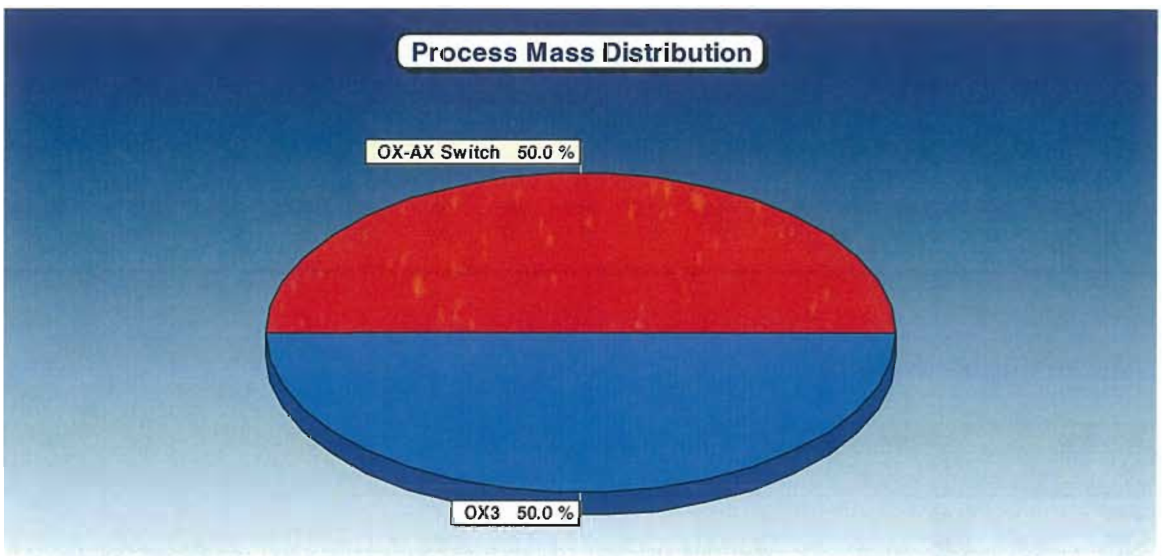
Elements	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Kjeldahl Nitrogen [mgN/L]	Total P [mgP/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total N [mgN/L]	PO4-P (Sol. & Me Complexed) [mgP/L]
primary	445.46	230.83	144.74	126.53	36.19	14.17	28.31	0.19	36.38	11.97

clarifiers										
AX1	4688.67	1180.04	4916.33	3732.77	228.47	274.21	4.26	0.38	228.94	6.52
OX-AX Switch	4687.14	1176.03	4906.13	3732.36	228.47	274.21	4.63	0.01	228.49	9.71
OX1	4677.33	1171.76	4908.49	3730.29	227.11	274.21	3.01	0.98	228.33	8.29
OX2	4671.01	1168.41	4910.11	3727.64	225.95	274.21	1.74	1.99	228.21	6.92
OX3	4665.64	1165.20	4911.23	3724.95	225.11	274.21	0.86	2.83	228.10	5.71
Effluent	35.50	0.70	0.02	0.01	1.62	4.65	0.40	3.31	5.01	4.65

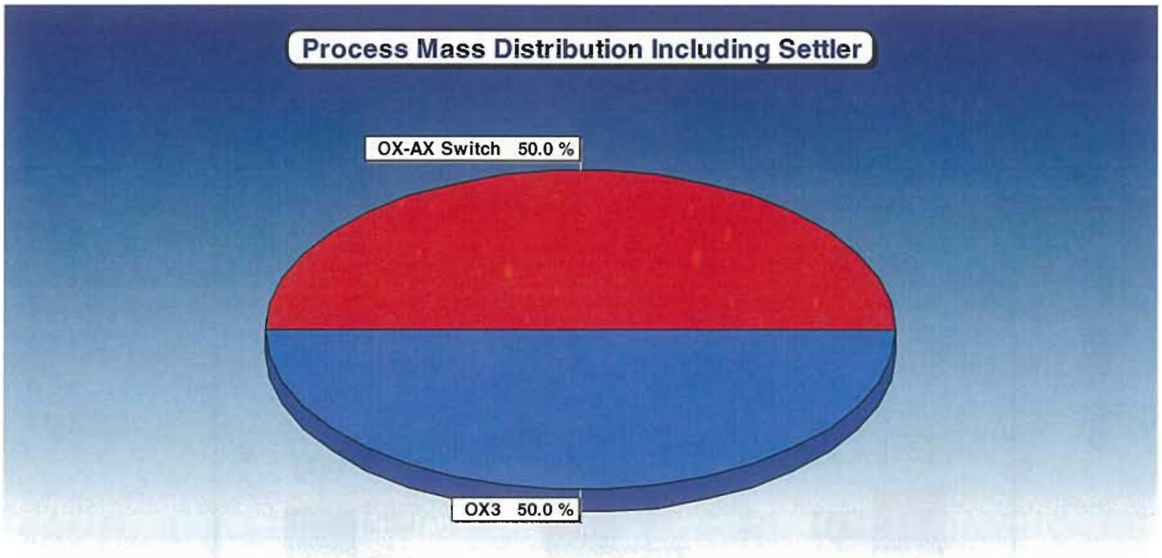
Album page - Tables

Elements	Total COD [lb /d]	Total Carbonaceous BOD [lb /d]	Total suspended solids [lb TSS/d]	Volatile suspended solids [lb VSS/d]	Total Kjeldahl Nitrogen [lb N/d]	Total N [lb N/d]	Soluble PO4-P [lb P/d]	Total P [lb P/d]
OX-AX Switch	1482183.10	371887.32	1551432.10	1180257.50	72247.84	72253.97	3070.61	86712.34
OX3	1475381.70	368464.30	1553044.30	1177915.10	71184.36	72130.51	1805.05	86712.34
Effluent	1527.21	30.09	0.78	0.59	69.67	215.39	200.18	200.23
Dewatered Sludge	11869.46	1718.54	12109.72	10021.86	382.55	382.55	29.51	230.40

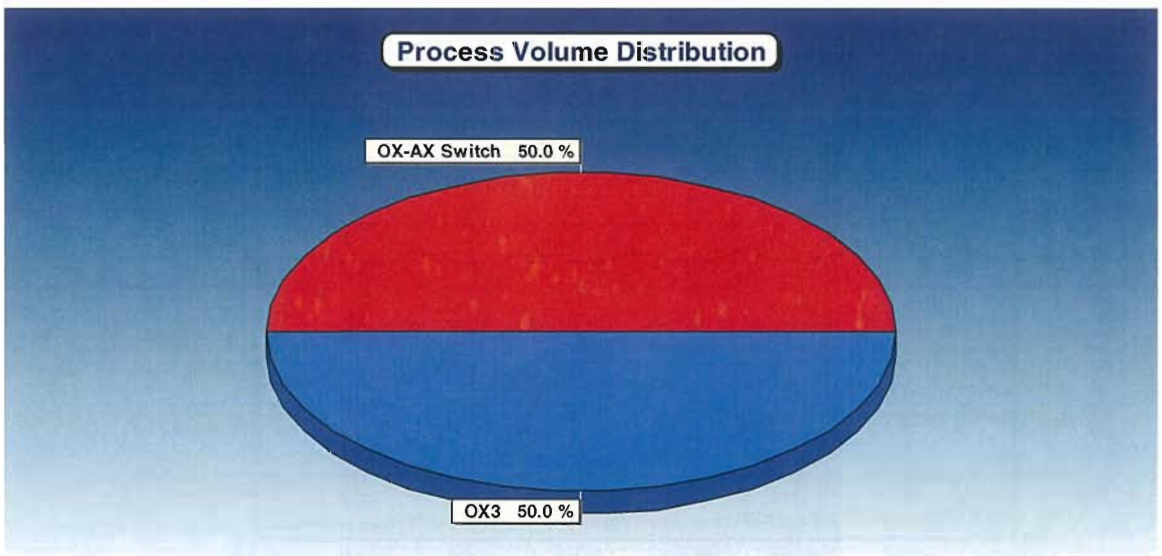
Album page - Mass Dist-Process Only



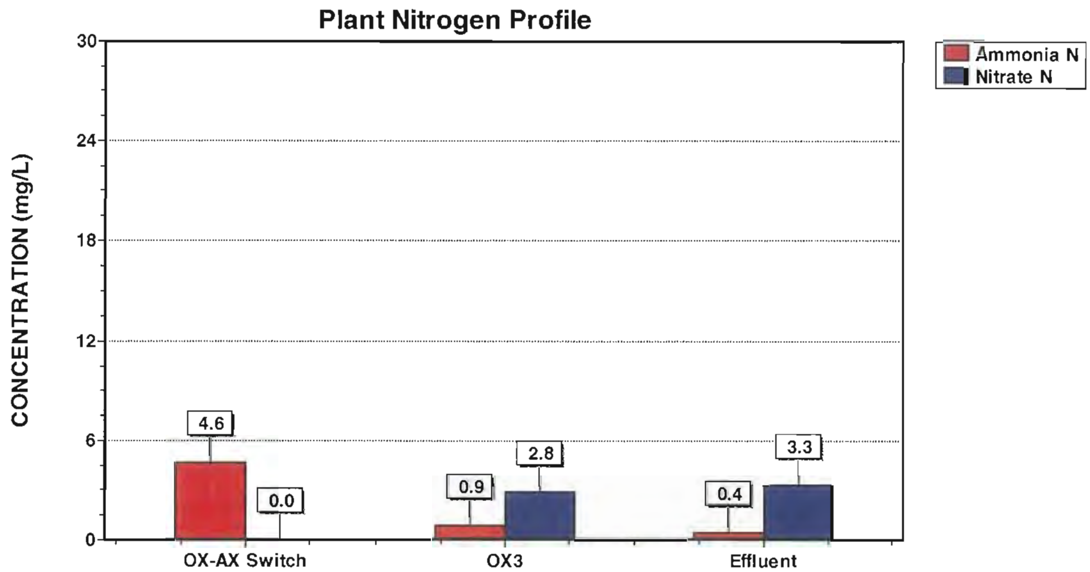
Album page - Mass Dist-Incl. Settler



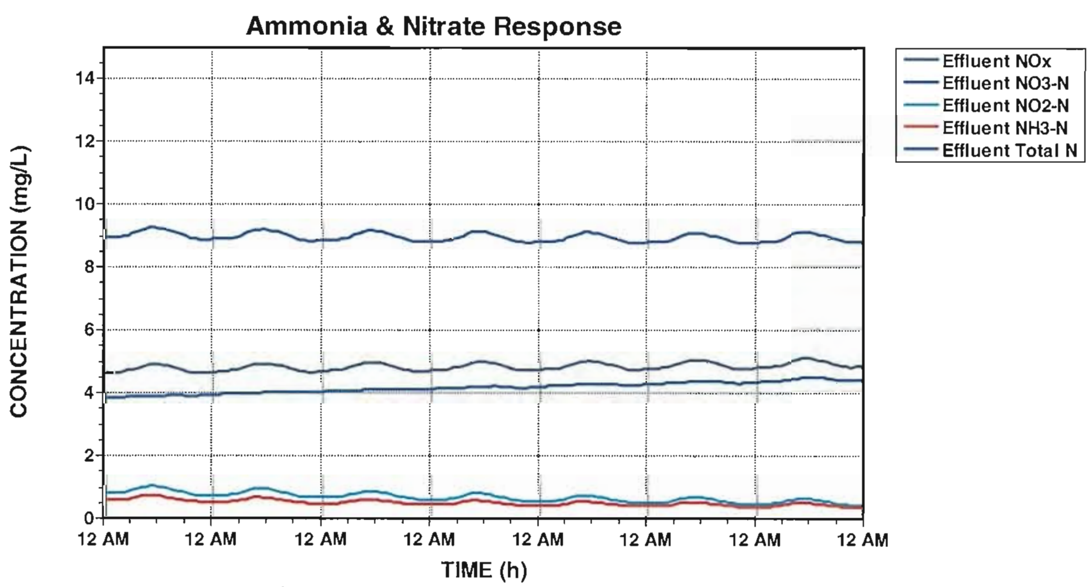
Album page - Volume Dist



Album page - N Profile



Album page - Dynamic Chart



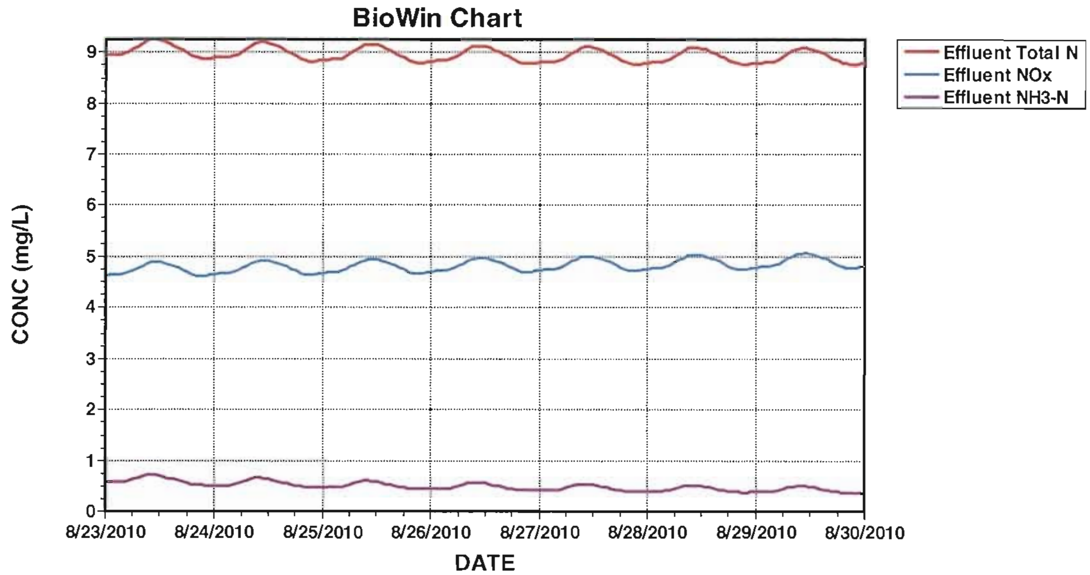
Album page - Page 8

OX-AX Switch			
Parameters	Conc. (mg/L)	Mass rate (lb/d)	Notes
Volatile suspended solids	3732.36	1180257.50	
Total suspended solids	4906.13	1551432.10	
Particulate COD	4644.86	1468812.30	
Filtered COD	42.28	13370.83	
Total COD	4687.14	1482183.10	
Soluble PO4-P	9.71	3070.61	
Total P	274.21	86712.34	
Filtered TKN	5.63	1781.54	

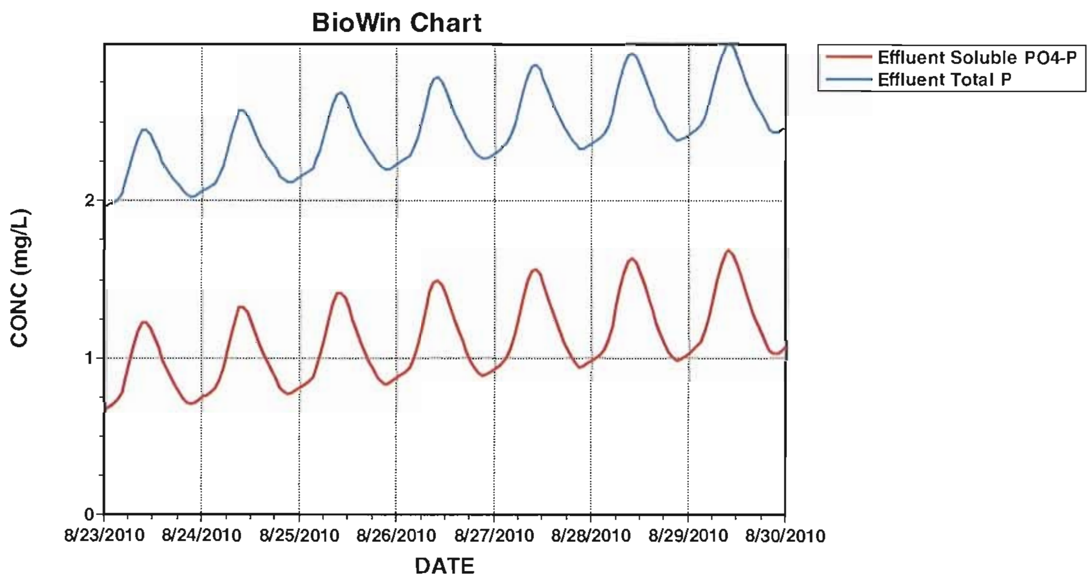
Particulate TKN	222.84	70466.31	
Total Kjeldahl Nitrogen	228.47	72247.84	
Filtered Carbonaceous BOD	2.49	788.64	
Total Carbonaceous BOD	1176.03	371887.32	
Nitrite + Nitrate	0.02	6.13	
Total N	228.49	72253.97	
Total inorganic N	4.65	1469.80	
Alkalinity	4.52	648.85	mmol/L and kmol/d
pH	7.00		
Volatile fatty acids	1.75	554.87	
Total precipitated solids	0	0.00	
Total inorganic suspended solids	1173.77	371174.58	
Ammonia N	4.63	1463.67	
Nitrate N	0.01	4.31	

Parameters	Value	Units
Hydraulic residence time	0.3	hours
Flow	37.89	mgd
MLSS	4906.13	mg/L
Total solids mass	17605.77	lb
Total readily biodegradable COD	3.49	mg/L
Total oxygen uptake rate	0.01	mgO/L/hr
Carbonaceous OUR	0.01	mgO/L/hr
Nitrogenous OUR	0.00	mgO/L/hr
Net. ammonia removal rate	-1.34	mgN/L/hr
Nitrate production rate	0.00	mgN/L/hr
Nitrite production rate	1.36	mgN/L/hr
Nitrate removal rate	1.36	mgN/L/hr
Nitrite removal rate	1.66	mgN/L/hr
Net. nitrate production rate	-1.36	mgN/L/hr
Net. nitrite production rate	-0.31	mgN/L/hr
Dissolved N2 gas production rate	1.66	mgN/L/hr
Spec. dissolved N2 gas production rate per VSS	0.45	mgN/gVSS/hr
Spec. dissolved N2 gas production per VASS	1.20	mgN/gVASS/hr
OTE	100.00	%
OTR	0	lb/hr
SOTE	100.00	%
SOTR	0	lb/hr
Air supply rate	0	ft3/min (20C, 1 atm)
Air flow rate / diffuser	0	ft3/min (20C, 1 atm)
# of diffusers	0	
Off gas flow rate (dry)	5.22	ft3/min
Oxygen content	0	%
Carbon dioxide content	60.45	%
Ammonia content	0.01	%
Actual DO sat. conc.	8.43	mg/L
Velocity gradient	92.03	1/s

Album page - EffTN



Album page - EffTP



Album page - ExportData

Elements Non-polyP heterotrophs [mgCOD/L] Anoxic methanol utilizers [mgCOD/L] Ammonia oxidizing biomass [mgCOD/L] Nitrite oxidizing biomass [mgCOD/L] Anaerobic ammonia oxidizers [mgCOD/L] PolyP heterotrophs [mgCOD/L] Propionic acetogens [mgCOD/L] Acetoclastic methanogens [mgCOD/L] Hydrogenotrophic methanogens [mgCOD/L] Endogenous products [mgCOD/L] Slowly bio. COD (part.) [mgCOD/L] Slowly bio. COD (colloid.) [mgCOD/L] Part. inert. COD [mgCOD/L] Part. bio. org. N [mgN/L] Part. bio. org. P [mgP/L] Part. inert N [mgN/L] Part. inert P [mgP/L] Stored PHA [mgCOD/L] Releasable stored polyP [mgP/L] Fixed stored polyP [mgP/L] PolyP bound cations [mg/L] Readily bio. COD (complex) [mgCOD/L] Acetate [mgCOD/L] Propionate [mgCOD/L] Methanol [mgCOD/L] Dissolved H2 [mgCOD/L] Dissolved methane [mg/L] Ammonia N [mgN/L] Sol. bio. org. N [mgN/L] Nitrite N [mgN/L] Nitrate N [mgN/L] Dissolved nitrogen gas [mgN/L] PO4-P (Sol. & Me

Complexed) [mgP/L] Sol. inert COD [mgCOD/L] Sol. inert TKN [mgN/L] Inorganic S.S. [mgISS/L] Struvite [mgISS/L] Hydroxy-dicalcium-phosphate [mgISS/L] Hydroxy-apatite [mgISS/L] Magnesium [mg/L] Calcium [mg/L] Metal [mg/L] Other Cations (strong bases) [meq/L] Other Anions (strong acids) [meq/L] Total CO2 [mmol/L] User defined 1 [mg/L] User defined 2 [mg/L] User defined 3 [mgVSS/L] User defined 4 [mgISS/L] Dissolved oxygen [mg/L] Flow [mgd] Liquid volume [Mil. Gal] Temperature [deg. C] Volatile suspended solids [mgVSS/L] Total suspended solids [mgTSS/L] Particulate COD [mg/L] Filtered COD [mg/L] Total COD [mg/L] Soluble PO4-P [mgP/L] Total P [mgP/L] Filtered TKN [mgN/L] Particulate TKN [mgN/L] Total Kjeldahl Nitrogen [mgN/L] Filtered Carbonaceous BOD [mg/L] Total Carbonaceous BOD [mg/L] Nitrite + Nitrate [mgN/L] Total N [mgN/L] Total inorganic N [mgN/L] Alkalinity [mmol/L] pH [] Volatile fatty acids [mg/L] Total precipitated solids [mgTSS/L] Total inorganic suspended solids [mgTSS/L]

Digester 1		2771.76	4.99	82.51	52.52	5.88	1166.53	4.39	344.28	253.87	4223.46
	8454.99	0.01	15126.33	285.95	98.26	151.26	166.39	752.65	0.23	98.53	67.58
	0.09	297.39	1.39	0	0.02	36.85	345.18	0.34	0.00	0.00	0.11
	661.62	78.60	3.53	4054.48	0	0	0	144.40	74.19	0	15.73
	9.82	53.90	0	0	0	0	0.00	0.06	0.37	35.00	26516.47
	31421.19	33244.16	377.50	33621.66	661.62	1216.44	349.04	1054.02	1403.06	211.10	7744.18
	0.00	1403.06	345.18	24.77	7.00	298.77	0	4904.72			
Digester 2		879.27	3.83	45.64	29.05	4.93	923.58	5.98	348.40	226.14	4562.84
	4095.77	0.00	15126.33	176.82	58.07	151.26	166.39	596.23	0.00	78.01	53.49
	0.14	77.96	4.46	0	0.01	25.40	549.04	0.45	0.00	0.00	0.00
	761.75	115.04	6.08	4054.48	0	0	0	149.28	75.53	0	17.50
	11.36	68.32	0	0	0	0	0.00	0.06	0.37	35.00	22683.48
	27409.15	26848.01	197.61	27045.63	761.75	1216.44	555.57	817.15	1372.71	58.31	3942.94
	0.00	1372.71	549.04	37.30	7.00	82.42	0	4725.67			
OX-AX Switch		1470.40	0.52	43.01	26.86	0.66	433.27	0.14	0.38	0.46	981.54
	67.61	0.04	1602.51	2.83	0.90	16.03	17.63	17.50	146.16	36.70	124.28
	1.74	0.50	1.26	0	4.63	0.05	4.63	0.59	0.01	0.01	18.23
	9.71	34.12	0.41	429.54	0	0	0	20.88	40.24	0	5.79
	5.00	6.22	0	0	0	0	0.00	37.89	0.43	20.00	3732.36
	4906.13	4644.86	42.28	4687.14	9.71	274.21	5.63	222.84	228.47	2.49	1176.03
	0.02	228.49	4.65	4.52	7.00	1.75	0	1173.77			
OX3	1470.84	0.52	43.29	27.03	0.66	435.07	0.13	0.37	0.46	984.35	52.21
	0.00	1602.51	2.66	0.83	16.03	17.63	12.62	149.95	36.87	126.96	1.05
	0.00	0.00	0	0.19	0.01	0.86	0.77	0.16	2.83	15.76	5.71
	34.34	0.43	429.54	0	0	0	19.95	39.99	0	5.75	5.00
	5.78	0	0	0	0	1.00	37.89	0.43	20.00	3724.95	4911.23
	4630.06	35.58	4665.64	5.71	274.21	2.07	223.04	225.11	0.74	1165.20	2.99
	228.10	3.86	4.05	7.00	0.00	0	1186.28				
OX1	1471.62	0.52	43.14	26.92	0.66	433.97	0.14	0.37	0.46	982.47	61.68
	0.00	1602.51	2.78	0.88	16.03	17.63	15.88	147.47	36.77	125.21	1.31
	0.02	0.05	0	1.42	0.02	3.01	0.69	0.24	0.98	16.50	8.29
	34.19	0.42	429.54	0	0	0	20.55	40.15	0	5.77	5.00
	6.01	0	0	0	0	1.00	37.89	0.43	20.00	3730.29	4908.49
	4640.33	37.00	4677.33	8.29	274.21	4.12	222.99	227.11	0.98	1171.76	1.23
	228.33	4.23	4.33	7.00	0.07	0	1178.20				
OX2	1471.53	0.52	43.24	26.98	0.66	434.57	0.14	0.37	0.46	983.41	56.56
	0.00	1602.51	2.72	0.86	16.03	17.63	14.18	148.77	36.82	126.13	1.13
	0.00	0.00	0	0.49	0.01	1.74	0.74	0.26	1.99	15.95	6.92
	34.27	0.42	429.54	0	0	0	20.23	40.06	0	5.76	5.00
	5.88	0	0	0	0	1.00	37.89	0.43	20.00	3727.64	4910.11
	4635.12	35.89	4671.01	6.92	274.21	2.91	223.04	225.95	0.80	1168.41	2.26
	228.21	4.00	4.16	7.00	0.00	0	1182.47				
OX4	1469.69	0.52	43.29	27.04	0.66	435.49	0.13	0.37	0.45	985.28	48.58
	0.00	1602.51	2.60	0.81	16.03	17.63	11.22	150.98	36.90	127.69	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65
	34.41	0.43	429.54	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	37.89	0.43	20.00	3722.29	4911.88
	4625.22	35.48	4660.70	4.65	274.21	1.62	223.00	224.62	0.70	1162.09	3.39
	228.00	3.79	3.99	7.00	0.00	0	1189.59				
AX1	1473.16	0.52	43.05	26.89	0.66	433.43	0.14	0.38	0.46	981.08	70.30
	0.67	1602.51	2.85	0.91	16.03	17.63	12.36	149.27	36.72	126.40	7.60
	0.27	0.11	0	0.99	0.04	4.26	0.77	0.09	0.38	17.99	6.52
	34.09	0.41	429.54	0	0	0	20.14	40.04	0	5.76	5.00
	6.21	0	0	0	0	0.00	37.89	0.43	20.00	3732.77	4916.33
	4644.93	43.74	4688.67	6.52	274.21	5.44	223.03	228.47	6.11	1180.04	0.47
	228.94	4.74	4.47	7.00	0.38	0	1183.56				
Effluent	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65

	34.41	0.43	0.00	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	5.16	0	20.00	0.01	0.02
	0.02	35.48	35.50	4.65	4.65	1.62	0.00	1.62	0.70	0.70	3.39
	5.01	3.79	3.99	7.00	0.00	0	0.00				
MLR	1469.69	0.52	43.29	27.04	0.66	435.49	0.13	0.37	0.45	985.28	48.58
	0.00	1602.51	2.60	0.81	16.03	17.63	11.22	150.98	36.90	127.69	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65
	34.41	0.43	429.54	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	28.42	0	20.00	3722.29	4911.88
	4625.22	35.48	4660.70	4.65	274.21	1.62	223.00	224.62	0.70	1162.09	3.39
	228.00	3.79	3.99	7.00	0.00	0	1189.59				
secondary clarifier underflow			3422.42	1.20	100.80	62.97	1.54	1014.10	0.31	0.86	1.05
	2294.39	113.12	0.00	3731.72	6.05	1.89	37.32	41.05	26.12	351.59	85.93
	297.34	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31
	15.70	4.65	34.41	0.43	1000.25	0	0	0	19.69	39.92	0
	5.74	5.00	5.74	0	0	0	0	0.80	4.06	0	20.00
	8667.97	11438.14	10770.60	35.48	10806.08	4.65	632.37	1.62	519.29	520.91	0.70
	2705.19	3.39	524.29	3.79	3.99	7.00	0.00	0	2770.16		
primary sludge		6769.54	6.49	26.33	18.77	6.60	229.30	6.42	21.08	15.92	610.15
	20325.90	79.49	13543.01	305.76	132.14	135.43	148.97	30.09	64.37	18.90	56.66
	135.44	24.61	0.04	0	0.01	0.23	28.31	3.57	0.00	0.19	15.83
	11.97	32.01	0.27	3630.08	0	0	0	21.18	40.32	0	5.86
	5.06	7.49	0	0	0	0	0.05	0.04	0	20.00	30281.90
	34640.68	41609.61	271.60	41881.21	11.97	538.93	32.15	967.25	999.40	169.23	14912.94
	0.20	999.59	28.51	6.08	7.00	24.65	0	4358.78			
recycles	116.28	0.07	3.57	2.24	0.09	39.44	0.05	2.65	1.73	107.81	34.40
	0.00	233.25	1.52	0.50	2.33	2.57	5.32	11.27	3.34	9.93	0.87
	10.74	0.61	0	0.08	3.50	75.98	0.74	0.07	2.85	13.53	108.96
	45.52	1.21	62.52	0.00	0.00	0.00	37.55	44.82	0	7.36	5.88
	14.36	0	0	0.00	0.00	0.69	0.37	0	20.00	448.22	572.50
	546.89	57.82	604.71	108.96	132.49	77.94	22.78	100.72	8.63	124.49	2.92
	103.64	78.91	8.50	7.00	11.36	0.00	124.28				
filter backwash		107.91	0.04	3.18	1.99	0.05	31.98	0.01	0.03	0.03	72.35
	3.57	0.00	117.67	0.19	0.06	1.18	1.29	0.82	11.09	2.71	9.38
	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70
	4.65	34.41	0.43	31.54	0.00	0.00	0.00	19.69	39.92	0	5.74
	5.00	5.74	0	0	0.00	0.00	0.80	0.26	0	20.00	273.31
	360.66	339.61	35.48	375.09	4.65	24.45	1.62	16.37	17.99	0.70	85.97
	3.39	21.38	3.79	3.99	7.00	0.00	0.00	87.35			
digester feed		9554.09	6.50	149.16	94.94	7.01	1473.30	5.31	17.21	13.51	3403.14
	15677.99	60.75	15126.33	241.40	103.41	151.26	166.39	56.43	499.24	124.44	423.90
	103.74	18.81	0.03	0	0.02	0.18	21.73	2.91	0.02	0.93	15.80
	10.24	32.58	0.31	4054.48	0	0	0	20.83	40.23	0	5.83
	5.04	7.08	0	0	0	0	0.22	0.06	0	20.00	34236.82
	41113.69	45584.93	215.93	45800.86	10.24	1216.44	24.95	1403.88	1428.83	129.49	14858.54
	0.95	1429.78	22.68	5.58	7.00	18.84	0.00	6876.87			
Thickened WAS		18578.84	6.54	547.22	341.83	8.34	5505.12	1.69	4.65	5.72	12455.25
	614.09	0.00	20257.90	32.83	10.26	202.58	222.84	141.79	1908.63	466.49	1614.14
	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70
	4.65	34.41	0.43	5429.95	0.00	0.00	0.00	19.69	39.92	0	5.74
	5.00	5.74	0	0	0.00	0.00	0.80	0.01	0	20.00	47054.72
	62092.75	58468.96	35.48	58504.44	4.65	3412.25	1.62	2819.00	2820.62	0.70	14682.23
	3.39	2824.00	3.79	3.99	7.00	0.00	0.00	15038.03			
WAS	3422.42	1.20	100.80	62.97	1.54	1014.10	0.31	0.86	1.05	2294.39	113.12
	0.00	3731.72	6.05	1.89	37.32	41.05	26.12	351.59	85.93	297.34	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65
	34.41	0.43	1000.25	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	0.08	0	20.00	8667.97	11438.14
	10770.60	35.48	10806.08	4.65	632.37	1.62	519.29	520.91	0.70	2705.19	3.39
	524.29	3.79	3.99	7.00	0.00	0	2770.16				
AX1 feed	1466.27	0.52	43.08	26.91	0.66	433.40	0.14	0.38	0.46	980.61	60.63
	11.51	1602.51	2.77	0.89	16.03	17.63	11.18	150.25	36.72	127.07	20.46
	3.57	0.01	0	0.07	0.04	4.44	1.19	0.07	2.86	15.72	5.71
	34.06	0.41	429.54	0	0	0	19.91	39.98	0	5.75	5.01
	6.00	0	0	0	0	0.69	37.89	0	20.00	3721.58	4907.72
	4626.75	69.68	4696.43	5.71	274.21	6.04	222.44	228.48	25.10	1189.48	2.92
	231.41	7.37	4.29	7.00	3.57	0	1186.15				
influent with recycles			80.19	0.08	0.31	0.22	0.08	2.72	0.08	0.25	0.19
	7.23	240.78	79.49	160.43	3.62	1.57	1.60	1.76	0.36	0.76	0.22
	0.67	135.44	24.61	0.04	0	0.01	0.23	28.31	3.57	0.00	0.19

	15.83	11.97	32.01	0.27	43.00	0	0	0	21.18	40.32	0
	5.86	5.06	7.49	0	0	0	0	0.05	5.53	0	20.00
	358.72	410.36	492.91	271.60	764.52	11.97	18.21	32.15	11.46	43.60	169.23
	343.88	0.20	43.80	28.51	6.08	7.00	24.65	0	51.63		
primary clarifiers		28.29	0.03	0.11	0.08	0.03	0.96	0.03	0.09	0.07	2.55
	84.93	79.49	56.59	1.28	0.55	0.57	0.62	0.13	0.27	0.08	0.24
	135.44	24.61	0.04	0	0.01	0.23	28.31	3.57	0.00	0.19	15.83
	11.97	32.01	0.27	15.17	0	0	0	21.18	40.32	0	5.86
	5.06	7.49	0	0	0	0	0.05	5.49	0.65	20.00	126.53
	144.74	173.86	271.60	445.46	11.97	14.17	32.15	4.04	36.19	169.23	230.83
	0.20	36.38	28.51	6.08	7.00	24.65	0	18.21			
Thickening Centrifuge			207.42	0.07	6.11	3.82	0.09	61.46	0.02	0.05	0.06
	139.05	6.86	0.00	226.16	0.37	0.11	2.26	2.49	1.58	21.31	5.21
	18.02	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31
	15.70	4.65	34.41	0.43	60.62	0	0	0	19.69	39.92	0
	5.74	5.00	5.74	0	0	0	0	0.80	0.06	0	20.00
	525.33	693.22	652.76	35.48	688.24	4.65	42.70	1.62	31.47	33.09	0.70
	164.60	3.39	36.48	3.79	3.99	7.00	0.00	0	167.89		
belt press	47.96	0.21	2.49	1.58	0.27	50.38	0.33	19.00	12.33	248.87	223.40
	0.00	825.04	9.64	3.17	8.25	9.08	32.52	0.00	4.25	2.92	0.14
	77.96	4.46	0	0.01	25.40	549.04	0.45	0.00	0.00	0.00	761.75
	115.04	6.08	221.15	0	0	0	149.28	75.53	0	17.50	11.36
	68.32	0	0	0	0	0.00	0.05	0	20.00	1237.24	1494.99
	1464.38	197.61	1662.00	761.75	786.55	555.57	44.57	600.14	58.31	270.19	0.00
	600.14	549.04	37.15	7.00	82.42	0	257.75				
filters	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65
	34.41	0.43	0.00	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	5.16	0	20.00	0.01	0.02
	0.02	35.48	35.50	4.65	4.65	1.62	0.00	1.62	0.70	0.70	3.39
	5.01	3.79	3.99	7.00	0.00	0	0.00				
Dewatered Sludge		10027.70	43.70	520.52	331.32	56.27	10533.07	68.19	3973.39	2579.08	52037.17
	46710.43	0.00	172509.20		2016.53	662.23	1725.09	1897.60	6799.79	0.00	889.64
	610.06	0.14	77.96	4.46	0	0.01	25.40	549.04	0.45	0.00	0.00
	0.00	761.75	115.04	6.08	46239.58	0.00	0.00	0.00	149.28	75.53	0
	17.50	11.36	68.32	0	0	0.00	0.00	0.00	0.00	0	20.00
	258695.13		312589.30		306189.82		197.61	306387.44		761.75	5947.27
	555.57	9319.21	9874.78	58.31	44360.79	0.00	9874.78	549.04	37.15	7.00	82.42
	0.00	53894.17									
RAS	3422.42	1.20	100.80	62.97	1.54	1014.10	0.31	0.86	1.05	2294.39	113.12
	0.00	3731.72	6.05	1.89	37.32	41.05	26.12	351.59	85.93	297.34	0.98
	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70	4.65
	34.41	0.43	1000.25	0	0	0	19.69	39.92	0	5.74	5.00
	5.74	0	0	0	0	0.80	3.98	0	20.00	8667.97	11438.14
	10770.60	35.48	10806.08	4.65	632.37	1.62	519.29	520.91	0.70	2705.19	3.39
	524.29	3.79	3.99	7.00	0.00	0	2770.16				
secondary clarifier feed			1469.69	0.52	43.29	27.04	0.66	435.49	0.13	0.37	0.45
	985.28	48.58	0.00	1602.51	2.60	0.81	16.03	17.63	11.22	150.98	36.90
	127.69	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31
	15.70	4.65	34.41	0.43	429.54	0	0	0	19.69	39.92	0
	5.74	5.00	5.74	0	0	0	0	0.80	9.47	0	20.00
	3722.29	4911.88	4625.22	35.48	4660.70	4.65	274.21	1.62	223.00	224.62	0.70
	1162.09	3.39	228.00	3.79	3.99	7.00	0.00	0	1189.59		
AX2 feed	1473.16	0.52	43.05	26.89	0.66	433.43	0.14	0.38	0.46	981.08	70.30
	0.67	1602.51	2.85	0.91	16.03	17.63	12.36	149.27	36.72	126.40	7.60
	0.27	0.11	0	0.99	0.04	4.26	0.77	0.09	0.38	17.99	6.52
	34.09	0.41	429.54	0	0	0	20.14	40.04	0	5.76	5.00
	6.21	0	0	0	0	0.00	37.89	0	20.00	3732.77	4916.33
	4644.93	43.74	4688.67	6.52	274.21	5.44	223.03	228.47	6.11	1180.04	0.47
	228.94	4.74	4.47	7.00	0.38	0	1183.56				
Inf	77.60	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0	255.61
	85.20	155.20	3.77	1.64	1.55	1.71	0	0.01	0	0.01	145.11
	25.61	0	0	0	0	24.89	3.77	0	0	16.00	5.00
	31.04	0.20	41.60	0	0	0	20.00	40.00	0	5.75	5.00
	7.00	0	0	0	0	0	5.16	0	20.00	352.29	398.71
	489.04	286.96	776.00	5.00	10.00	28.86	10.64	39.50	180.77	359.65	0
	39.50	24.89	5.90	7.00	25.61	0	46.41				
influent	77.60	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0	255.61
	85.20	155.20	3.77	1.64	1.55	1.71	0	0.01	0	0.01	145.11

	25.61	0	0	0	0	24.89	3.77	0	0	16.00	5.00
	31.04	0.20	41.60	0	0	0	20.00	40.00	0	5.75	5.00
	7.00	0	0	0	0	0	5.16	0	20.00	352.29	398.71
	489.04	286.96	776.00	5.00	10.00	28.86	10.64	39.50	180.77	359.65	0
	39.50	24.89	5.90	7.00	25.61	0	46.41				
Secondary Clarifier	5.14	0.00	0.15	0.09	0.00	1.52	0.00	0.00	0.00	3.45	
	0.17	0.00	5.61	0.01	0.00	0.06	0.06	0.04	0.53	0.13	0.45
	0.98	0.00	0.00	0	0.09	0.00	0.40	0.79	0.08	3.31	15.70
	4.65	34.41	0.43	1.50	0	0	0	19.69	39.92	0	5.74
	5.00	5.74	0	0	0	0	0.80	5.41	5.27	20.00	13.03
	17.19	16.19	35.48	51.67	4.65	5.60	1.62	0.78	2.40	0.70	4.76
	3.39	5.79	3.79	3.99	7.00	0.00	0	4.16			

APPENDIX C

TROUBLESHOOTING REPORT

CITY OF PRESCOTT	Sundog WWTP Upgrade Project
Title: **Troubleshooting Report - DRAFT**	Rev. 1
	Revision Date: Nov 11, 2009
	Review by B&V (initial): KA
	Review by Project Manager: DB
	Review by City of Prescott:
	Final Submitted to Client (Yes/No):

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TABLES

FIGURES

LIST OF ACRONYMS

Acronym	Definition
ADEQ	Arizona Department of Environmental Quality
cfd	Cubic feet per day
DAF	Dissolved air floatation thickener
FOGs	Fats, oils, and greases
FTE	Fulltime equivalent
gpd	Gallons per day
H_2S	Hydrogen sulfide
IC	Internal combustion
kW	Kilowatt
MG	Million gallons
MMBtu	Million BTU
MGD	Million gallons per day
NOx	Nitrogen Oxides (NO_3, NO_2, N_2O)
ppm	Part per million
psi	Pounds per square inch
scfm	Standard cubic feet per minute
TKN	Total Kjeldahl Nitrogen
TWAS	Thickened waste activated sludge
VOC	Volatile Organic Compound
WAS	Waste activated sludge
WWTP	Waste Water Treatment Plant

1.0 INTRODUCTION

1.1 ADEQ Total Water Quality Standards

There are operational challenges with the City of Prescott - Sundog WWTP. The key current issue is maintaining compliance with the ADEQ Total Nitrogen standard.

Table 1-1 ADEQ Water Quality Standards

Parameter	Treatment Standards
	Existing Class B+
Turbidity, NTU	
Average	NA
Single Sample Maximum	NA
Fecal Coliform, cfu/100mL	
4 of last 7 samples	200
Single Sample Maximum	800
Total Nitrogen Alert Level, mg/L	
5 samples geometric mean	8

1.2 Site Visit

B&V and Carollo attended site on November 9, 2009 to further understand operational issues. Discussions were held with City of Prescott Sundog WWTP Management, Operations and Laboratory staff to assimilate observations and unusual operating conditions experienced in the past.

2.0 EXISTING INFORMATION

2.1 Site Schematic

A simplified site schematic showing key unit processes evaluated in the troubleshooting are provided in Figure 2-1 for reference purposes.

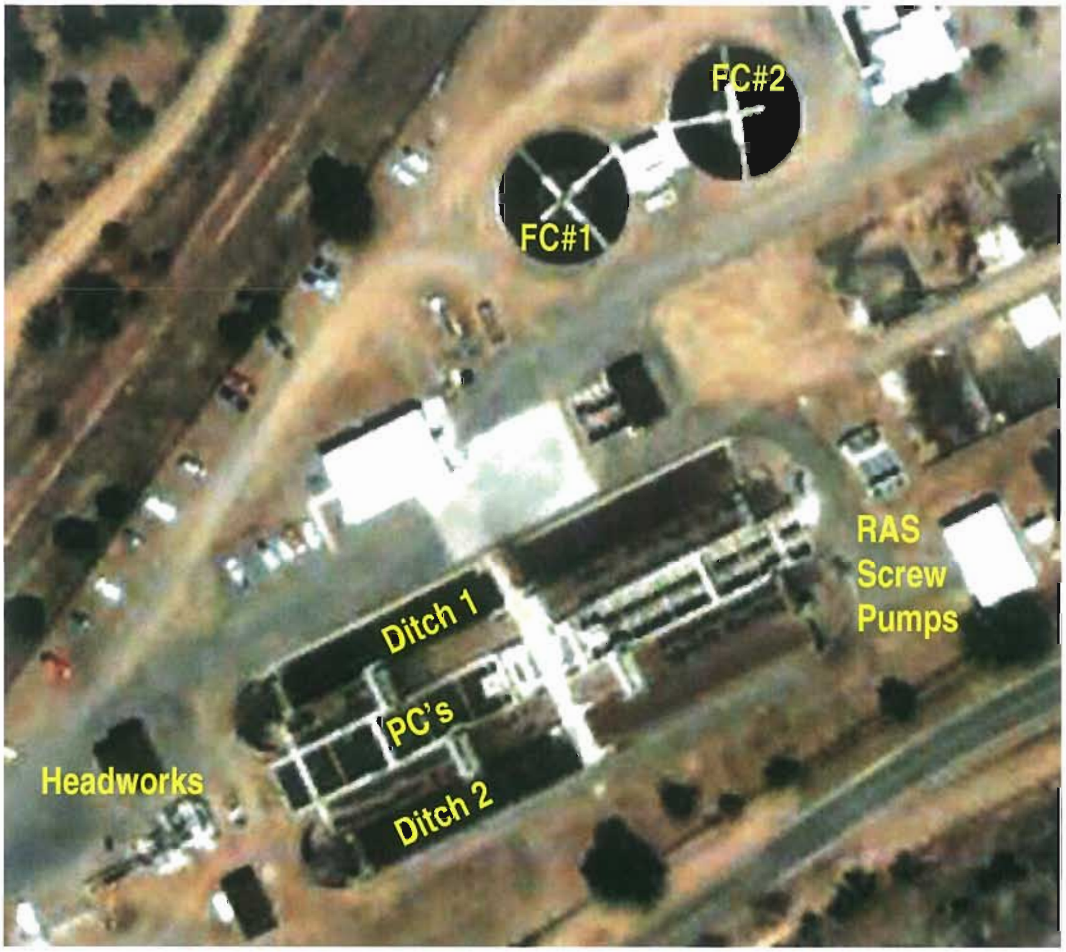

Figure 2-1 : Sundog Site Schematic

2.2 DO Profiles

High dissolved oxygen (DO), greater than 0.25 mg/L in the anoxic zones of a nitrogen removal system prevents or inhibits denitrification. This occurs because heterotrophic bacteria that perform denitrification prefer to use oxygen directly for growth purposes, rather than the oxygen contained in nitrate. Plant staff conducted multiple DO profiles in both oxidation ditches to track dissolved oxygen as one factor for reduced denitrification.

In the figures that follow the DO in the anoxic zones are dashed lines.

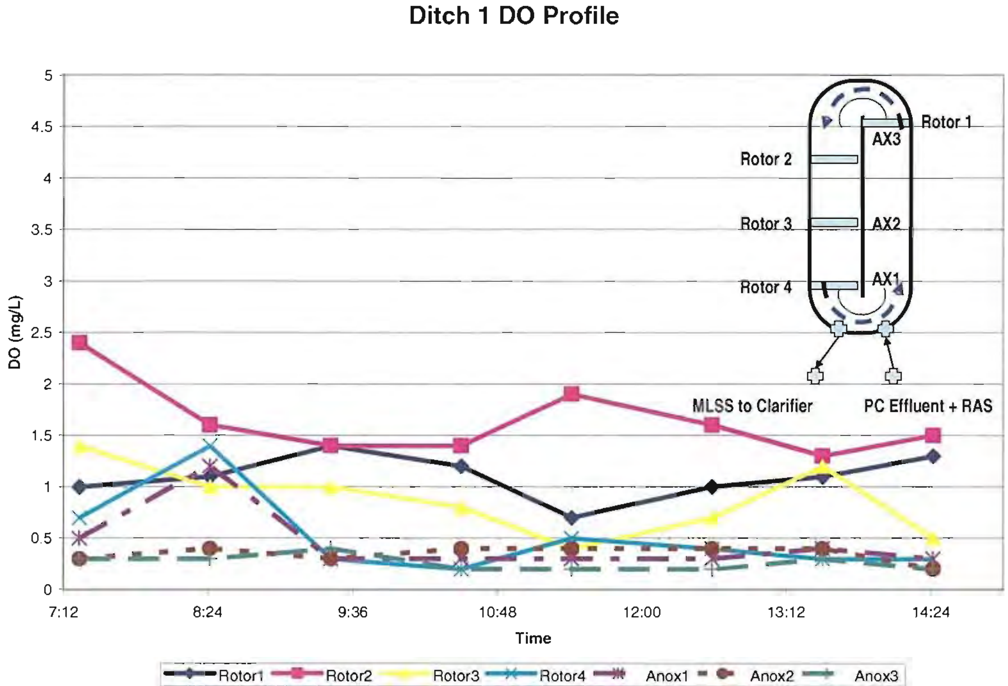

Figure 2-2 - Ditch 1 DO Profile: Oct 7, 2009

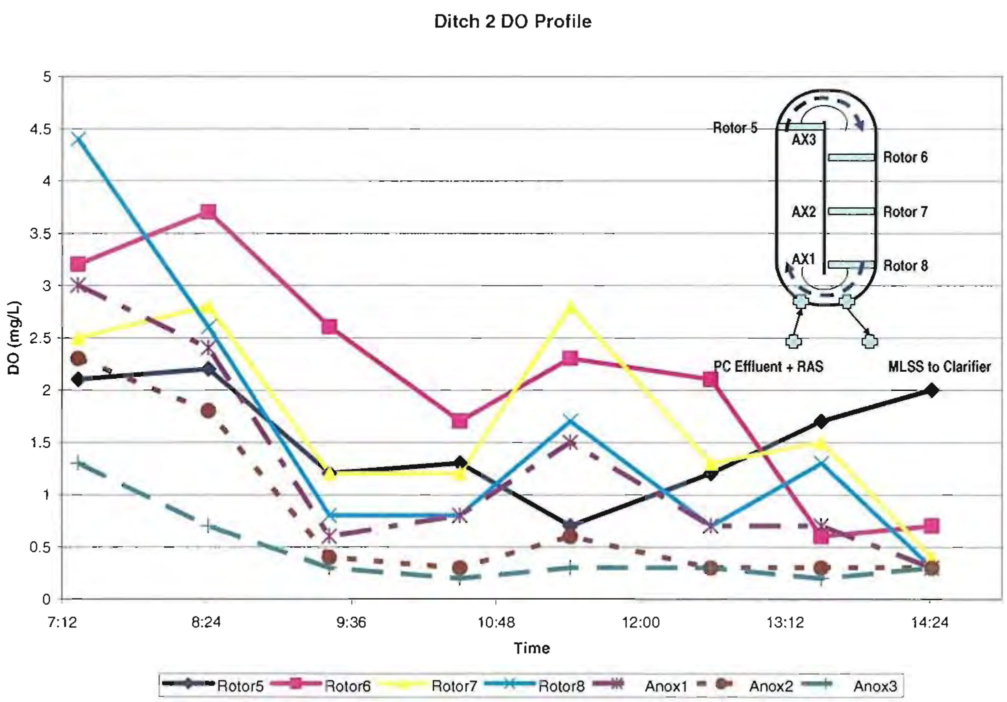

Figure 2-3 - Ditch 2 DO Profile: Oct 7, 2009

The average DO values for ditch 1 and 2 oxic and anoxic zones shown in Figure 2-4 illustrate the fact that Ditch 1 is typically lower in DO for both the oxic and anoxic zones.

Figure 2-4 - Both Ditches Average DO Profile: Oct 7, 2009

Control of DO is not automatic. DO is introduced into the ditches through timed operation of the mechanical rotors and timed operation of the blowers and coarse bubble aeration system. Typically operators set timers for equipment operation and thereafter sample DO concentration using portable DO probes in specific locations. On-line DO instrumentation is not available.

The current timer settings for the Rotor operation in ditches 1 and 2 are as follows:

Table 2-1 Sundog WWTP Rotor Operation Schedule			
Ditch 1		***Ditch 2***	
Rotor 1	On: 24 hrs	Rotor 5	On: 24 hrs
Rotor 2	On: 7am to 10 pm On: 15min/Off 1 hr 10 pm - 7 am	Rotor 6	On: 7am to 8 pm On: 15min/Off 1 hr 8 pm - 7 am
Rotor 3	On: 15min/Off 2 hr: 9am - 10pm Off: 10 pm - 9 am	Rotor 7	On: 15min/Off 2 hr: 9am - 8pm Off: 8 pm - 9 am
Rotor 4	On: 7:45 - 8:45 for ML samples	Rotor 8	On: 7:45 - 8:45 for ML samples

The current timer settings for the blower operation in ditches 1 and 2 are for 2 hours on between 9 am and 11 am each day. On certain days operators may elect to operate the blowers for 4 hours but this is not typical.

The reduced rotor operation in ditch 2 is not controlling DO in the anoxic zones.

2.3 *Temperature Profiles*

Temperature was monitored simultaneously with DO in the October 7, 2009 profile.

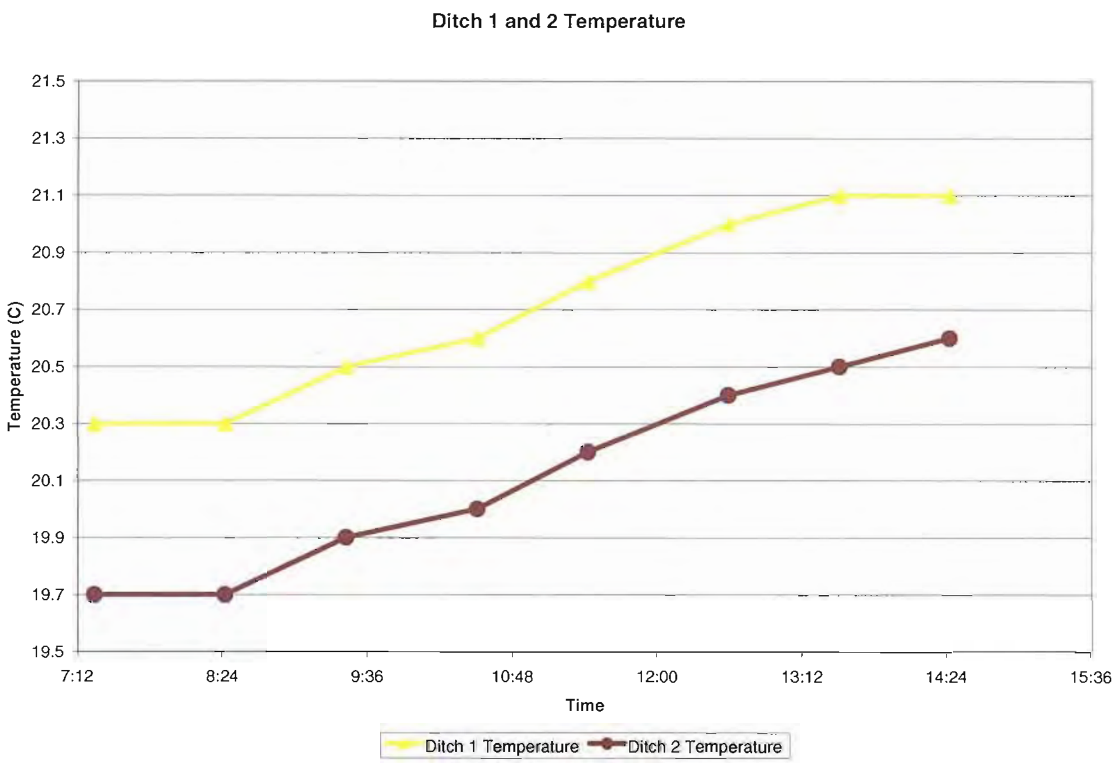

Figure 2-5 Ditch 1 and 2 Temperature Profile: Oct 7, 2009

This 0.6^0 C temperature difference is significant, not for biological process reasons, but as an indicator of dissimilar operation.

2.4 *Flow Split between Ditches 1 and 2*

Operators noticed that the two ditches were receiving unequal flows. This is observed by noticing the flow over the V-notch weirs on the two secondary clarifiers. Each ditch discharges MLSS to an individual secondary clarifier. (It is possible to cross-over effluent from the ditches and combine MLSS into one or both clarifiers but this is typically not used except in maintenance periods).

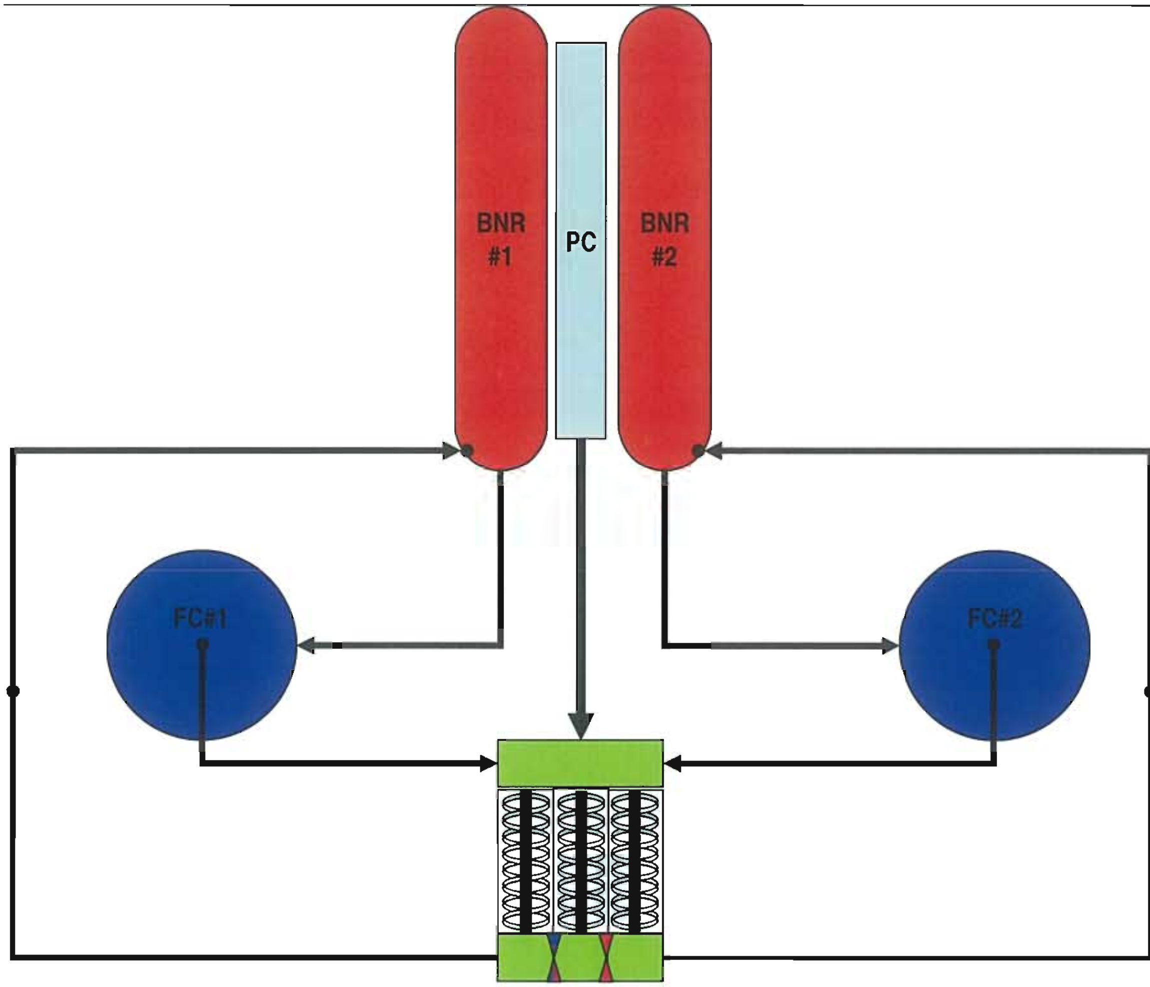

Figure 2-6 Sundog WWTP Flow Split Schematic

The flow path into the ditches is as follows:

- Primary effluent combines with RAS from the two final clarifiers in a wetwell
- Fixed speed inclined screw pumps lift the combined primary effluent and RAS into a distribution box.
- Flow in the distribution box is split hydraulically to the two ditches. There is no weir or flow control.
- Two gates are installed in the box for the purpose of isolating the ditches.

Figure 2-7 Sundog WWTP Flow Splitter

Operators have attempted to correct the flow mal-distribution by throttling flow to ditch 1 using the isolation gate. This is a difficult operation given that the flow difference must be observed at the clarifier v-notch weirs and then gate position adjusted. In addition, even with accurate observation and gate set, the flow split will only be approximately equal for the influent flow conditions that are approximately equal to the same flow as during the adjustment period.

3.0 SITE INVESTIGATIONS

3.1 Strategy

Based on the operational data collected and denitrification theory a number of hypotheses were developed:

- Operating with only one rotor for significant periods was reducing the internal mixed liquor recycle in the oxidation ditch to the point where effective denitrification no longer occurred
- DO concentrations in the basin over the diurnal low flow period (from midnight through 6:00 am) were elevated and preventing denitrification
- Unequal flow split was hampering performance.

In order to investigate these hypotheses, it was determined that profiling the ditches at the low flow period (4:00/6:00 am) would provide information on both mixed liquor recycle and DO concentrations.

3.2 DO Profile

B&V returned to Sundog WWTP at 4:00 am and conducted a DO profile on both ditches 1&2 using the operations Hach LDO portable probe. In addition the DO of the RAS and PE in the flow splitter box was also measured. Results of the DO profile are provided in Figure 3-1. There was a substantial difference in DO concentration between ditches 1 and 2 at the low flow condition.

Observations for ditch 1 are as follows:

1. The DO in the anoxic zone only drops below 0.5 mg/L at the very end of the unaerated zone before rotor 1.
2. However the DO in the oxic zone drops to less than 0.2 mg/L by Rotor 3.
3. In other words the anoxic zone is mainly oxic while the oxic zone is half anoxic.
4. The first anoxic zone has a significantly higher DO than the last oxic zone DO (rotor 4) and the rotor 3 position.

Observations for ditch 2 are as follows:

5. The DO in the entire ditch is always aerobic. There is no opportunity for denitrification to occur.
6. Similar to ditch 1, the DO is lowest at rotor 7 and at the end of the anoxic zone.
7. The first anoxic zone also has a higher DO than the last oxic zone DO (rotor 8), and significantly higher than rotor 7 position.

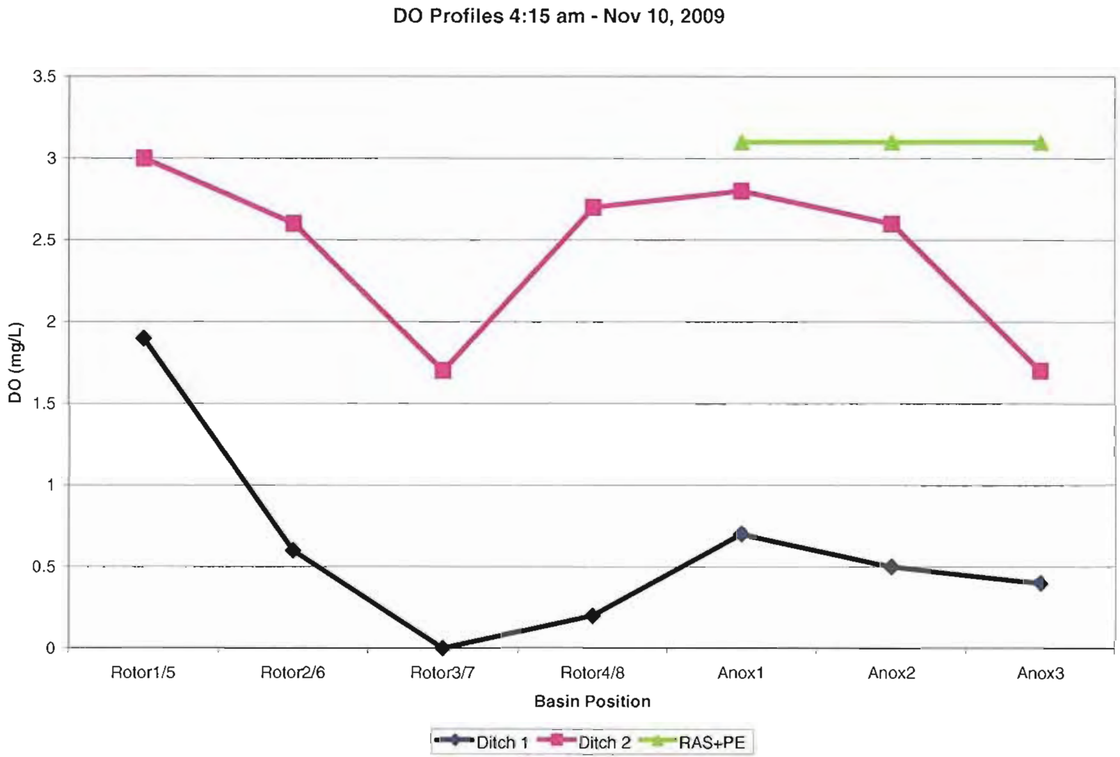

Figure 3-1 Ditches 1&2 DO Profile: Nov 10, 2009

3.3 DO Interpretation

3.3.1 Anoxic Zone DO Anomaly

At the low flow condition only about 300 gpm enters the WWTP. The RAS flow meters modulate to maintain a constant gravity RAS flow from each clarifier. This constant flow is approximately 700 gpm from each clarifier. A total flow of approximately 1,700 gpm is fed to the ditches. The screw pump aerates the RAS and influent in a similar manner to the rotors in the ditches, by thrashing the wastewater in air. The screw pump elevates DO above 3 mg/L. Therefore a constant contribution of DO is fed to the anoxic zones. The DO concentration is higher when influent flows are lower as the RAS is well stabilized and has a low oxygen requirement. This phenomenon explains why the anoxic zones are aerated.

In addition, under low flow conditions with only one rotor operating, the velocity of water in the ditch slows down. Therefore the influent flow appears to be ricocheting off the baffle wall and reversing direction into the aerobic zone at the position downstream of rotor 4/8. This is where DO was sampled.

Figure 3-2 Ditch Inner Ring Influent Flow Distributor

3.4 Temperature Profile

There was a consistent 0.3^0 C difference in temperature between ditch 1 and ditch 2. Ditch 2 was colder than ditch 1.

3.5 Internal Recycle and Clarifier Effluent Flow Observations

The flow at the end of the anoxic zone, just prior to Rotor 1/5 was observed for signs of settling. If the recycle flow was too low to keep MLSS in suspension then it is possible that high nitrates could result from the lack of intimate mixing between biomass and nitrate. However neither ditch showed signs of significant settling. Ditch 2 appeared to have approximately 4 inches of clarified effluent at rotor 5. Ditch 1 did not seem to have any settling.

Clarifier flows were significantly different. Flow could be observed leaving Clarifier 1 receiving MLSS from ditch 1 at the v-notch weirs. Virtually no flow could be observed leaving Clarifier 2, receiving MLSS from ditch 2. Flow split is definitely not equal at low flow conditions.

3.6 Clarifier Effluent Samples

Samples were extracted from each clarifier and ammonia and nitrate nitrogen values were measured by the Prescott WWTP laboratory chemist.

Table 3-1 Sundog WWTP Clarifier Grab Samples				
	SC#1 - Ditch 1		***SC#2 - Ditch 2***	
Time	NO3 - N	NH3 - N	NO3 - N	NH3 - N
4:00	2.6	3.19	7.8	0.25
6:00	2.5	3.05	13.4	0.26

These results are not surprising given the DO concentrations in the ditches. Ditch 2 operates essentially as an aerobic digester during the low flow condition and is oxidizing all ammonia and hydrolyzed TKN to nitrate. At the current unequal flow split Ditch 1 could possibly benefit from some increased aeration overnight to further oxidize ammonia. However this will be at the expense of more nitrate in the effluent. Given the high nitrates from ditch 2 additional aeration is not recommended.

When influent flow starts to increase during the morning, the high nitrates in the secondary clarifier will be washed into the final effluent and rapidly elevate the combined oxidized nitrogen values.

3.7 Surface Filamentous Foam

The surfaces of both ditches were partially covered with up to 4 inches of filamentous foam. This foam appeared to be predominantly *Microthrix parvicella* based on visual observation and prior analysis by Dr. Michael Richards. Foam collection was significant at the low flow condition at lower ditch velocities. This is probably because more foam can be trapped behind rotors at lower water velocity.

The ditches have a submerged outlet to the clarifiers. Therefore the accumulation of any amounts of foam can rapidly become a problem as there is no positive means of removing foam from the surface of the ditches. Operators utilize water sprays to assist in mechanically knocking down foam.

The tendency to foam and particularly the presence of *Microthrix parvicella* reduces the maximum MLSS or SRT that can be operated. This also prevents the ability of plant operators to raise MLSS to drive nitrification or denitrification as higher MLSS means uncontrollable foaming events.

Figure 3-3 Filamentous Foam on Oxidation Ditches

4.0 RECOMMENDATIONS

4.1 Resolve Flow Split

Until flow split is equalized it will be very difficult for operations staff to control nitrogen species in any meaningful way. Two initial options for resolving the flow split have been identified:

1. Install a launder in the flow splitter well that is of equal length. This option will require some means of connecting the launder to the existing pipe. One possible method of construction could be to install a plate in the well of either feed well to create a baffle box. Each launder would also require an isolation plate when a ditch must be removed from service. The existing gates would need to be removed and the separating walls would need to be partially demolished.
2. Install v-notch weirs for flow splitting by either constructing an extension on the external wall of the flow splitter or install a stainless v notch weir box on the downstream wall of the center well of the flow splitter. This second option requires the middle screw pump to operate to ensure equal flow split however. If flows increase and more than one pump is required to operate, or the middle screw pump fails the two outer screw pumps will be required to operate to maintain flow to each ditch.

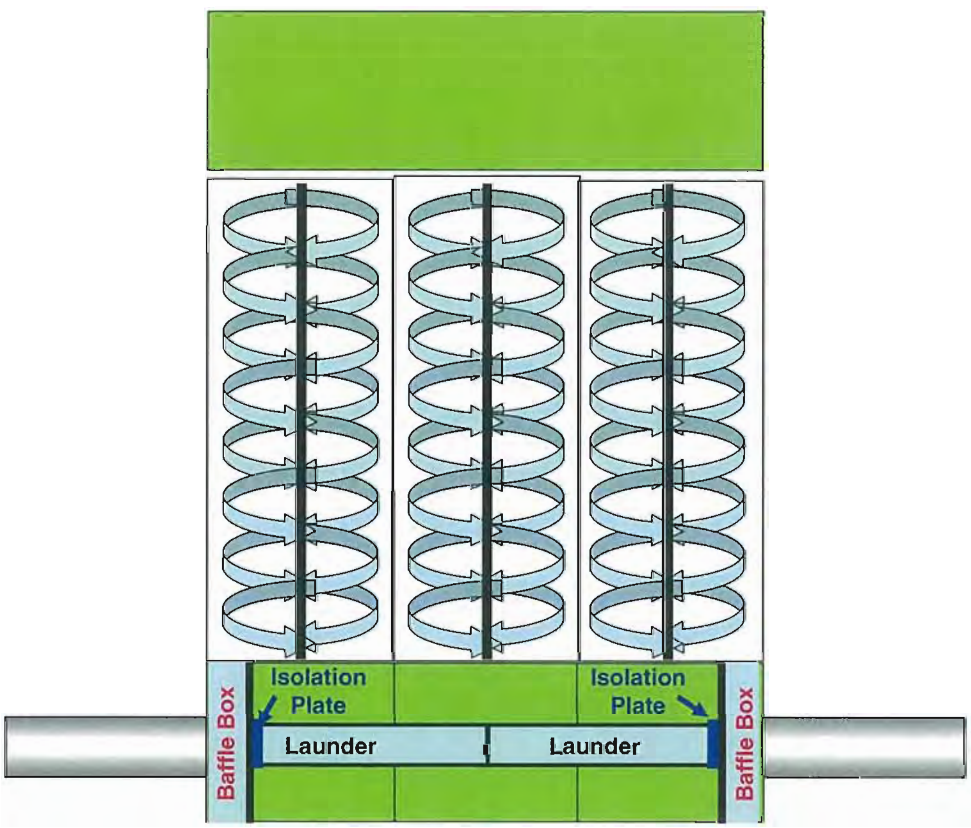

Figure 4-1 Flow Split Using Launders

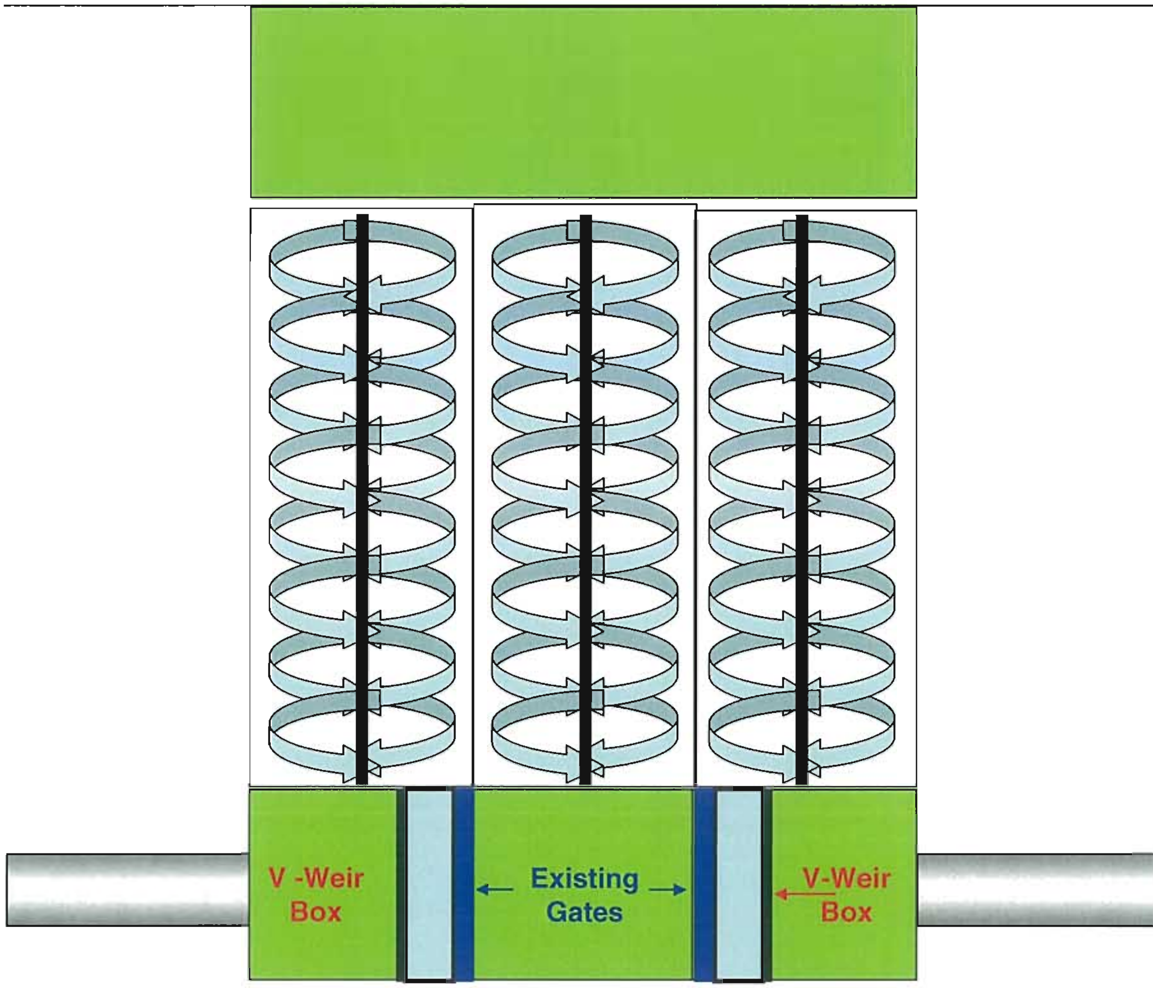

Figure 4-2 Flow Split using V-notch Weirs

4.2 *Improve DO Control*

There is no current automatic means of controlling DO in the ditches. This is necessary to ensure compliance with the Total N Alert Limit. In order to accomplish DO control the following is recommended:

- Install variable speed drives on all rotors
- Install at least 4 DO probes in the two ditches. Probes should be installed downstream of rotor 1 and 3; and 5 and 7. Supply long leads for these instruments as optimization of DO probe position will need to be made during commissioning
- Maintain the current blower configuration with manual isolation valves
- Install PLC control for DO control. Develop a custom algorithm that preferentially uses rotor aeration for provision of DO, and leave blower aeration as a backup for high demand conditions
- Install submersible mixers or high flow, low head axial pumps to generate water velocity without aerating the mixed liquor. Separating mixed liquor recycle and

aeration will provide additional control and optimization of denitrification. At low flow conditions, it may prove optimal to run a single rotor at minimum speed for DO control aeration purposes. This slow speed is unlikely to be sufficient for maintaining velocity and recycle in the ditch.

4.3 Test Polyaluminum Chloride addition for Microthrix Control

Research over the past decade has shown that Aluminum in the form found in aluminum chlorohydrate (ACH) or poly aluminum chloride (PACL) is effective in controlling the proliferation of *Microthrix parvicella*. One WWTP in Washington State (LOTT - Budd Inlet WWTP) has used ACH for the past five years in directed campaigns during colder weather for filament control. The main benefits of filament control will be the ability to increase MLSS in the oxidation ditches to further enhance nitrogen removal in the short term. In the long term successful deployment of ACH will provide the ability for removing one of the two ditches for sustained periods of time (3 months), irrespective of time of year, when maintenance work or process upgrades are required.

The dose of ACH is somewhat site and biomass specific. Therefore it is recommended that trial of ACH dosing be performed. The following dosing tables are based on Summachlor 50, an ACH product sold by Summit Research Labs in Phoenix Arizona[1].

Table 4-1 Summachlor 50 Characteristics	
[Al2O3]	23.50%
[Al]	12.4%
ACH (SG)	1.34
ACH Al3+	12.4%
AL3+ kg AL3+/L of ACH	0.17
gallons per tote	275
lbs/tote	3073
Cost per lb	$0.60
Tote cost	$1,843.97

Based on these characteristics the dosage rate is calculated as follows:

[1] (Mark Muser, Summit Research Labs, www.kemira.com, 410-356 5312)

Table 4-2 Summachlor 50 Dose Calculation	
Flow (mgd)	2.2
Ditch Volume (ft3)	700000
m3 of tankage	19822
Target Dose Al (g/kg of Biomass)	1
Design MLSS (kg/m3)	2.6
kg of biomass	51537
lbs of biomass	113517
kg/day of Al3+	51.5
kg/day of ACH	309.1
L/day of ACH	231
ACH gallons/day	61.0
ACH dose (mg/L)	37.1

The cost for applying this chemical for a three week period is estimated as follows:

Table 4-3 Summachlor 50 Cost for 21 day trial	
Total Summachlor 50 (gallons)	1280
Totes required	5
Cost	$ 9,220

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 3A
Airport WRF Existing Conditions

Final

In Association with

Project No. 164890

3033 NORTH 44TH STREET • SUITE 101 • PHOENIX, ARIZONA 85018 • (602) 263-9500 • FAX (602) 265-1422

City of Prescott

**TECHNICAL MEMORANDUM
NO. 3A
AIRPORT WRF EXISTING CONDITIONS**

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ES3A TM 3A – AIRPORT WRF EXISTING CONDITIONS

ES3A.1 Introduction

The purpose of this technical memorandum is to gather, organize, and document existing conditions for the Airport WRF, including available data, physical condition of existing facilities, existing treatment capacity, and operational issues. This memorandum serves as the foundation for defining and developing the design for the required near-term improvements at the Airport WRF. It also serves as the existing condition reference point for long-term treatment technologies and capacity assessments.

The original Airport WRF was constructed in 1978, and designed for a treatment capacity of 0.75 million gallons per day (mgd) Annual Average Daily Flow (AADF). The Airport WRF expansion project in 1998 was constructed for a treatment capacity of 2.25 mgd AADF, and included upgrades for denitrification and tertiary filtration. The purpose of the 1998 process upgrade was to continue to provide an effluent of suitable quality for golf course irrigation and aquifer recharge by means of existing recharge basins. The current Aquifer Protection Permit (APP) for the Airport WRF is based on an AADF of 2.2 mgd.

ES3A.2 Existing Information

Table ES3A.1 shows that the 1998 expansion design considered that the hydraulic capacity of the water reclamation facility would be increased in the future to accommodate the previously projected buildout flows.

Table ES3A.1 Previous Design Flows
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

	1998 Design	Buildout per 1998 Design
Annual average daily flow, mgd (average flow at start-up)	2.25 (0.65-0.75)	2.4
Maximum month average daily (design) flow, mgd	2.7	2.9
Maximum day flow, mgd	4.2	4.8
Hydraulic capacity, peak (hour), mgd	6.3	7.2
Minimum flow, mgd	0.8	0.8

Table ES3A.2 shows the wastewater characteristics used in the 1998 expansion design. The concentrations shown in Table ES3A.2 were based on plant records for 1992 and 1993 and additional influent sampling conducted in September 1995.

Table ES3A.2 Previous Design Wastewater Characteristics and Concentrations Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona

	Average		Maximum Month		Load Peaking Factor
Characteristics	**mg/L**	**ppd**	**mg/L**	**ppd**	
BOD_5	117	2,340	155	3,750	1.6
TSS	159	3,190	211	5,103	1.6
TKN	35	697	36	871	1.25
Temperature, °C					
Summer	25				
Winter	12				

The previous (1998) improvements to the Airport WRF consisted of the following facilities:

- Headworks: mechanical bar screen with manual screen bypass, parshall flume, and grit removal settling basin with grit screw.
- Oxidation ditches: anoxic basins, new oxidation ditch, and modifications to existing ditch
- Secondary clarifier and sludge pump station
- Traveling bridge filter
- UV Disinfection

Additional improvements in 2008 included modifications and upgrades to the following facilities:

- Sludge holding tank
- Solids handling (centrifuge) building

ES3A.3 Physical Conditions

A visual inspection of the major equipment and structures at the Airport WRF was conducted as part of this project. The intent of the inspection was to document the general condition of all major equipment and structures at the plant, to provide input for future improvements planning. The visual condition assessment of the major equipment and structures at the plant is summarized in Table ES3A.3. In general, most of the facilities at the Airport WRF can be considered in relatively good condition, with a few unit processes needing attention to resolve minor issues.

Table ES3A.3 Condition Assessment of Existing Facilities
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Unit Process	Structure Condition	Equipment Condition
Headworks		
Mechanical bar screen	Good	Good
Manual bar screen	Good	Good
Grit removal	Good	Good
Activated Sludge System		
Anoxic basins	Good	Good
Oxidation Ditch No. 1 (1998)	Good	Good
Oxidation Ditch No. 2 (1976)	Fair (1)	Fair (1)
Secondary clarifier	Good	Good
Tertiary filter	Good	Good (2)
UV Disinfection	Good	Good
Effluent and NPW Pumping		
Pump station / Wet well	Good	Good
Recovery Well Pump Station	Good	Good
Solids Handling		
Solids Holding Tank	Fair (3)	Good
Dewatering system	Good	Good

Notes:
(1) Minor cracks and concrete spalling were observed. The shotcrete thickness is 2.5 inches per the record drawings. Brush rotors showed some evidence of corrosion, and a few missing blades. Plant staff has recently performed maintenance on the equipment and equipment is in operation.
(2) Media replacement was performed in 2007. Plant staff reported that the filter underdrain system was in good condition at the time that the media was replaced.
(3) Minor cracks and concrete spalling were observed.

ES3A.4 Capacity Analysis

The capacity of existing facilities at the Airport WRF was estimated based on a detailed evaluation of the performance of each unit process using existing flow and loading conditions. Recent (2006 – 2009) plant operating data was used to establish existing hydraulic and loading criteria. The capacity of the Airport WRF was estimated using typical performance criteria and detailed process modeling.

Daily average, high, and low influent flows were obtained from plant operational data records between January 2006 and April 2009. The average daily flow into the plant has been consistently increasing over time. Throughout a calendar year, the plant typically receives higher flows during winter months, probably due to infiltration during wet weather months. The recommended design hydraulic peaking factors based on the plant data analyzed are presented in Table ES3A.4. The recommended peaking factors are similar to values observed in other typical domestic wastewater treatment facilities in Arizona.

Table ES3A.4 Design Hydraulic Peaking Factors
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Hydraulic Peaking Factor (1)	Value
Maximum Month Average Day	1.4
Peak Day	2.0
Peak Hour	3.0

Note:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

The wastewater characteristics for the plant capacity analysis were determined based on an analysis of the plant's historical wastewater quality records. Influent characteristics were obtained from plant operations historical records between 2006 and 2009.

Table ES3A.5 presents the wastewater characteristics at average and maximum month conditions, used for the capacity evaluation presented herein. Average and maximum month concentrations were based on a statistical analysis over the entire analysis period (2006 to 2009).

Table ES3A.5 Design Wastewater Concentrations
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott

Parameter	Unit	Annual Average Day (1)	Maximum Month Average Day (2)
Design Concentrations			
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity (3)	mg/L	250	250
Temperature (4)	°C	18.4	12.4
pH	--	7.3	7.3

Notes:
(1) Average wastewater concentrations were calculated over the analysis period (2006 to 2009).
(2) Based on the observation that the maximum month load (ppd) coincides with the maximum month flow (mgd).
(3) Assumed. No data available.
(4) Based on mixed liquor temperature measurements.

The existing wastewater concentrations are significantly higher than the criteria used for the design of the secondary treatment facilities in the 1998 expansion. The existing BOD and TSS wastewater concentrations are higher than the original design criteria values by factors ranging between 2.6 and 3.2. The existing average TKN concentrations are similar to the values used for the original design.

Additional sampling upstream of the WRF was performed by the City, in order to identify any possible sources of unusually high loadings (see TM 3A – Appendix C for sampling locations and results). Wastewater samples were collected at several points in the collection system in the vicinity of the Airport WRF. BOD and TSS values at the plant headworks agreed with recent elevated values.

The capacity of each process unit was evaluated by comparing its maximum capacity to the appropriate governing criterion. The estimated capacity was expressed in terms of average day flow using the appropriate peaking factors depending on the governing criterion particular for each unit process.

Figure ES3A.1 summarizes the capacity analysis estimate for the existing facilities at the Airport WRF. The current tertiary treatment facilities (filter and UV disinfection) limit the plant capacity at an average day flow capacity of 1.2 mgd. The current secondary treatment system has a capacity of 1.5 mgd mainly due to limitations in secondary clarification capacity.

ES3A.5 Operational Considerations

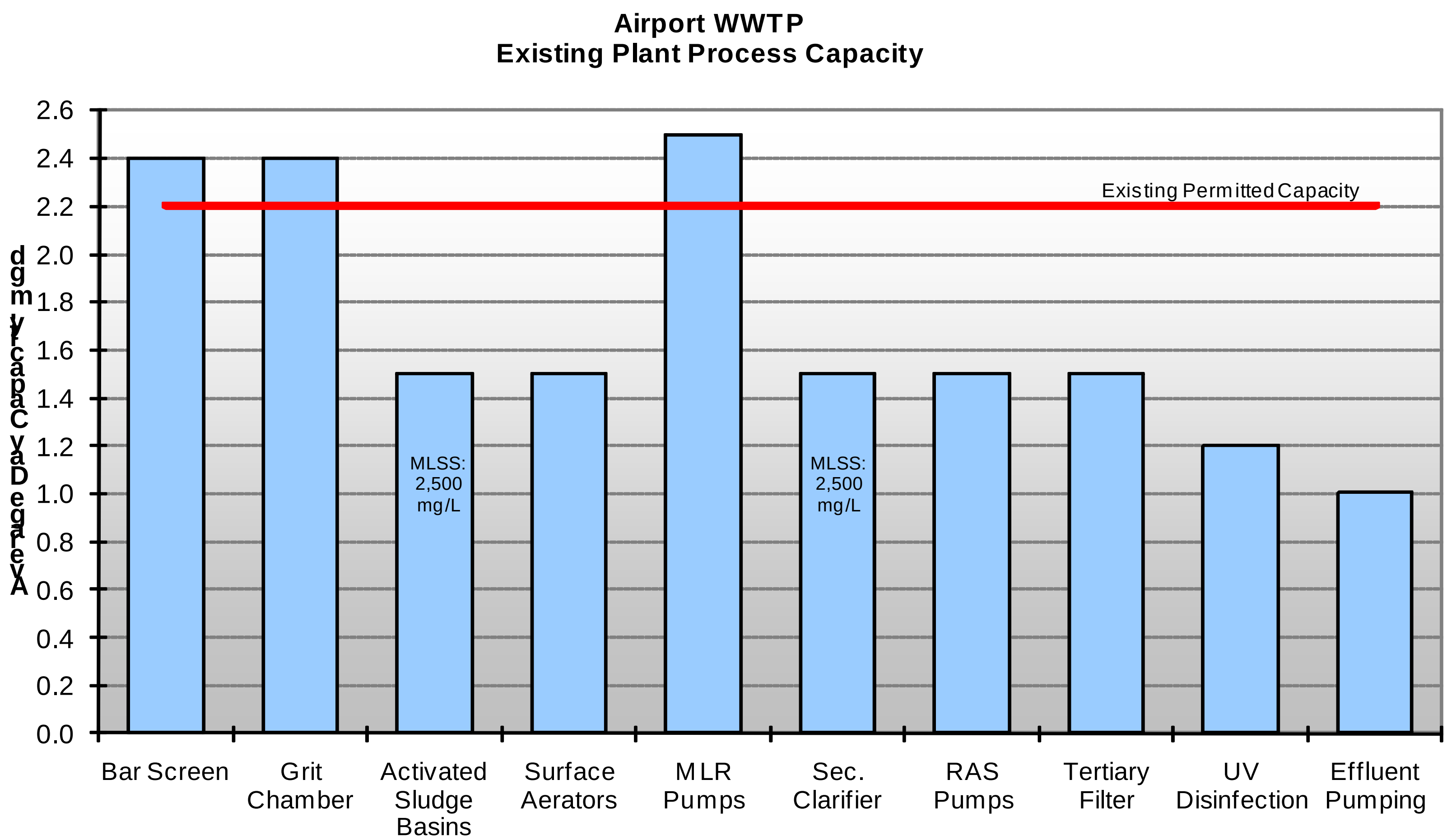
The screening equipment is currently operating without any major concerns. The grit removal equipment is in good working condition, other than a few minor mechanical repairs that have been required.

The plant had been operating with only the newer oxidation ditch basin (Oxidation Ditch No. 1) in service. The original oxidation ditch basin (Oxidation Ditch No. 2) was being used as an emergency equalization basin. Due to increased loadings in the plant influent, plant staff started operating Oxidation Ditch No. 2 at the end of 2008, in order to increase the aerobic solids retention time and improve the system operation, especially under winter conditions.

There is currently only one secondary sedimentation basin in operation. While the equipment is operating properly, there is no redundancy in the secondary clarification process. More clarification capacity is required not only to increase plant capacity, but also to provide redundancy. However, addition of secondary clarifier capacity needs to be evaluated within the context of the overall site master plan.

There is currently no redundancy in the filtration facilities. Specific recommendations regarding tertiary filtration are addressed in Technical Memorandum No. 7.

The plant does not currently have any type of SCADA monitoring or control system available. At the minimum, monitoring of key processes and alarms notifications are desirable in the short-term. Monitoring and alarms would improve the reliability of the system, providing operators the ability to identify major upsets during unattended operation periods. In the long-term, instrumentation and control elements could be incorporated in a plant control system for automation of the major processes, such as secondary process equipment. Automation of major processes will optimize energy consumption, and provide a more reliable operation of the treatment process.



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SUMMARY OF CAPACITY ANALYSIS ESTIMATE

FIGURE ES3A.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

1.0 INTRODUCTION

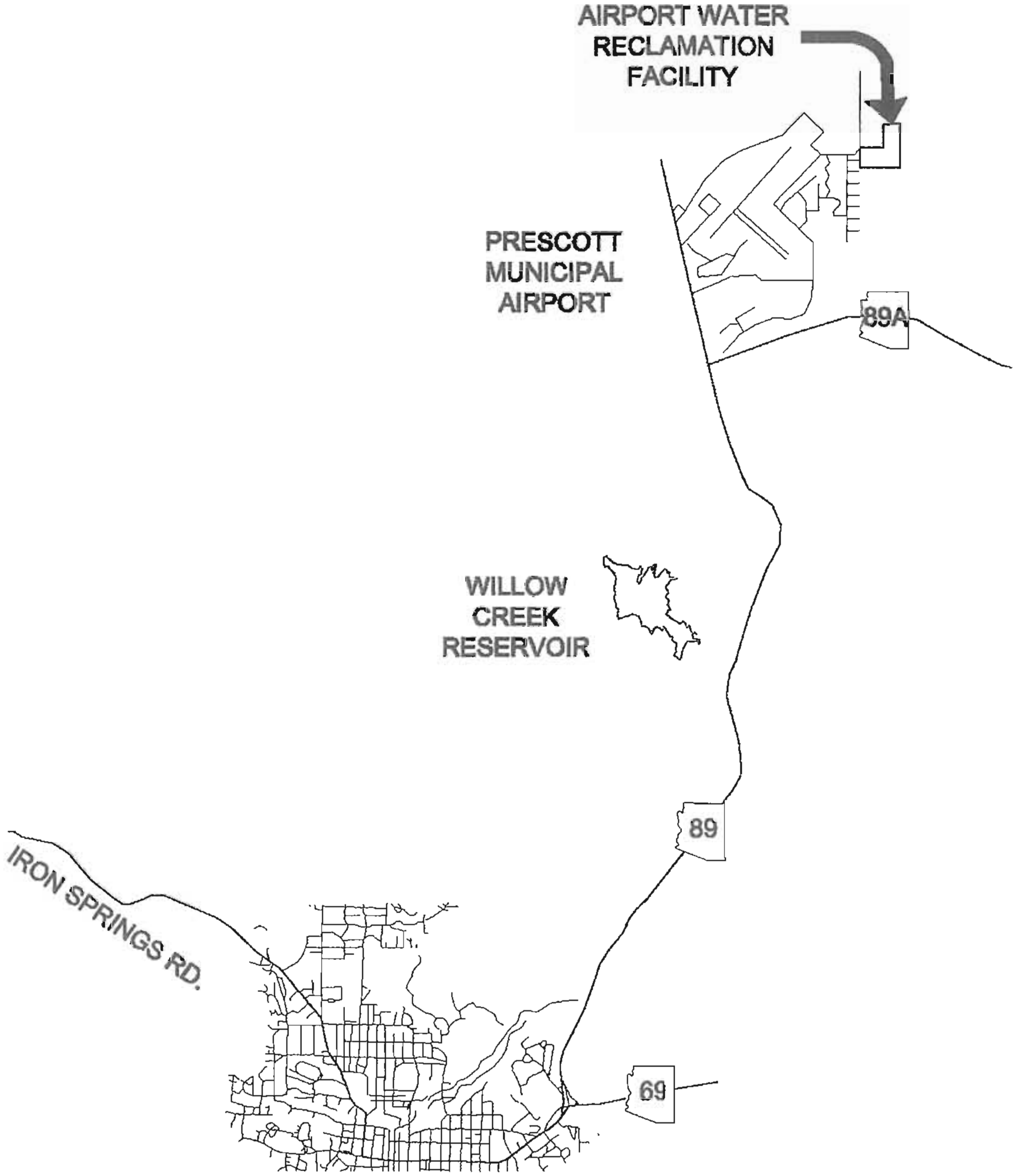
1.1 Project Scope

This technical memorandum is part of the Master Planning, Design, and Local Limits project for the City of Prescott Airport Water Reclamation Facility (WRF) and Sundog Wastewater Treatment Plant (WWTP). This TM No. 3A addresses Part 2 of the project, Airport WRF Near-Term Improvements, specifically Task Group 700 - Establish Existing Conditions, and Task Group 300 - Existing Facilities Assessment. The purpose of this technical memorandum is to gather, organize, and document existing conditions for the Airport WRF, including available data, physical condition of existing facilities, existing treatment capacity, and operational issues. This memorandum will serve as the foundation for defining and developing the design for the required near-term improvements at the Airport WRF. It will also serve as the existing condition reference point for long-term treatment technologies and capacity assessments.

1.2 Project Background

The City of Prescott is located in the mountains of north central Arizona, and borders the Prescott National Forest to the south and west. Prescott currently has three operating wastewater treatment and reclamation facilities: the Hassayampa Water Reclamation Plant (WRP), the Sundog WWTP, and the Airport WRF. The Hassayampa WRP was placed into service in 1999, is privately operated and its effluent is used to water a private golf course. The City's largest wastewater treatment plant, the Sundog WWTP, is located approximately 2 miles northeast of the City's centroid, and currently receives the majority of the City's wastewater flow. It was last upgraded in 1989. The third Prescott-owned wastewater treatment plant is the Airport WRF, which is located roughly 8 miles northeast of the City's centroid, adjacent (east) of the local airport, the Ernest A. Love Field. The physical location of the Airport WRF is delineated in Figure 3A.1.

The original Airport WRF was constructed in 1978, and designed for a treatment capacity of 0.75 million gallons per day (mgd) Annual Average Daily Flow (AADF). It consisted of a headworks (flow measurement, screening, and grit removal), a single oxidation ditch, a single clarifier, a sludge pumping station, a chlorine contact chamber for effluent disinfection, and an effluent pumping station.



LOCATION MAP

NOT TO SCALE

SITE LOCATION MAP

FIGURE 3A.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

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The Airport WRF expansion project in 1998 was designed for a treatment capacity of 2.4 mgd AADF. The liquid treatment process was upgraded to include denitrification and tertiary filtration. The purpose of the process upgrade was to continue to provide an effluent of suitable quality for golf course irrigation and aquifer recharge by means of existing recharge basins. It is important to point out that during the 1998 expansion project, due to budgetary constraints, one secondary clarifier and one tertiary filter were deleted from the project, limiting the plant's design capacity to 2.25 mgd AADF. The current Aquifer Protection Permit (APP) for the Airport WRF is based on an AADF of 2.2 mgd.

Waste Activated Sludge (WAS) from the Airport WRF was originally stored and dewatered in drying beds on-site. Currently, WAS is thickened, mechanically dewatered, and stored in roll-off containers at the Airport WRF site, for subsequent landfill disposal. Figure 3A.2 shows a general site plan of the Airport WRF.

2.0 EXISTING INFORMATION

2.1 Previous Design Documents

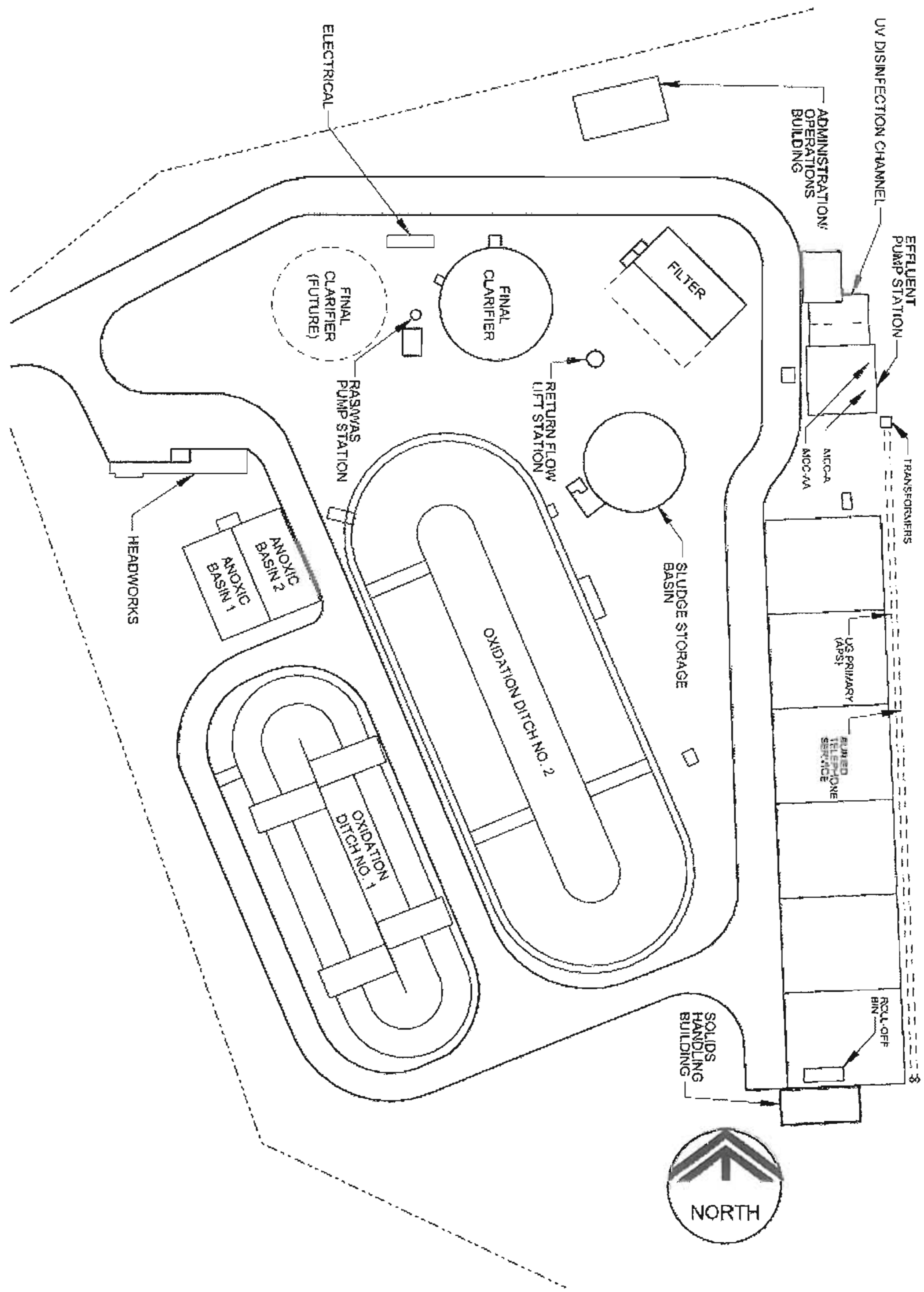
Numerous documents were gathered for the existing City of Prescott Airport WRF facility assessment. These documents included, but were not necessarily limited to the following.

- Airport WRF 0.75 mgd Contract Drawings, Carollo Engineers, 1976.
- Airport WRF Expansion Preliminary Design Memorandum, Black & Veatch, 1996.
- Airport WRF Expansion Contract Specifications, Black & Veatch, 1998.
- Airport WRF Expansion Contract Drawings, Black & Veatch, 1998.
- Airport WRF Expansion O&M Manual, Black & Veatch, 2000.
- Airport WRF Centrifuge Project, Contract Specifications, Brown and Caldwell, 2008.
- Airport WRF Centrifuge Project, Contract Drawings, Brown and Caldwell, 2008.
- Airport WRF Centrifuge Project, O&M Manual, Brown and Caldwell, 2008.
- Airport WRF Various Process Data, City of Prescott, 2006-2009.
- Airport WRF Various Meeting Notes, Carollo / Black & Veatch, 2008-2009.

2.2 Previous Basis of Design

2.2.1 Previous Hydraulic Criteria

At buildout of the service area, the expected daily average flow was estimated to be 2.4 mgd. The maximum month and minimum flow ratios were projected from plant operating data from 1992, 1993 and September of 1995. The hydraulic capacity was based on an hourly peaking factor of 3.



GENERAL SITE PLAN

FIGURE 3A.2

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

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Table 3A.1 shows that the 1998 expansion design considered that the hydraulic capacity of the water reclamation facility would be increased in the future to accommodate the previously projected buildout flows.

Table 3A.1 Previous Design Flows
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

	1998 Design	Buildout per 1998 Design
Annual average daily flow, mgd (average flow at start-up)	2.25 (0.65-0.75)	2.4
Maximum month average daily (design) flow, mgd	2.7	2.9
Maximum day flow, mgd	4.2	4.8
Hydraulic capacity, peak (hour), mgd	6.3	7.2
Minimum flow, mgd	0.8	0.8

2.2.2 Previous Wastewater Characteristics

The wastewater characteristics used for the previous (1998) expansion design were 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and Total Kjeldahl Nitrogen (TKN). The concentrations shown in Table 3A.2 were based on plant records for 1992 and 1993 and additional influent sampling conducted in September 1995. Table 3A.2 shows the wastewater characteristics used in the 1998 expansion design.

Table 3A.2 Previous Design Wastewater Characteristics and Concentrations
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

	Average		Maximum Month		Load Peaking Factor
Characteristics	mg/L	ppd	mg/L	ppd	
BOD_5	117	2,340	155	3,750	1.6
TSS	159	3,190	211	5,103	1.6
TKN	35	697	36	871	1.25
Temperature, °C					
Summer	25				
Winter	12				

2.2.3 Governing Codes

The City of Prescott adopted the 2006 International Building Codes (2006 IBC), which became effective October 15, 2007. In 2008, the City made amendments to the 2006 IBC, which have also been adopted. Previous design efforts were based on codes established in Prescott in 1993-1994. The previous and currently adopted codes are shown in Table 3A.3.

Table 3A.3	Governing Building Codes Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona
Previous Design Governing Codes	**Current Governing Codes (2007)**
1994 Uniform Building Code	2006 International Building Code (IBC) (1)
1994 Uniform Mechanical Code	2006 International Mechanical Code (IMC) (1)
1994 Uniform Plumbing Code	2006 International Plumbing Code (IPC) (1)
1994 Uniform Fire Code	2006 International Fire Code (IFC) (1)
1993 National Electric Code	2006 International Electrical Code (IEC) (1)
Note: (1) Amendments to the 2006 codes done in 2008 have been adopted by the City.	

2.3 Existing Facilities Description

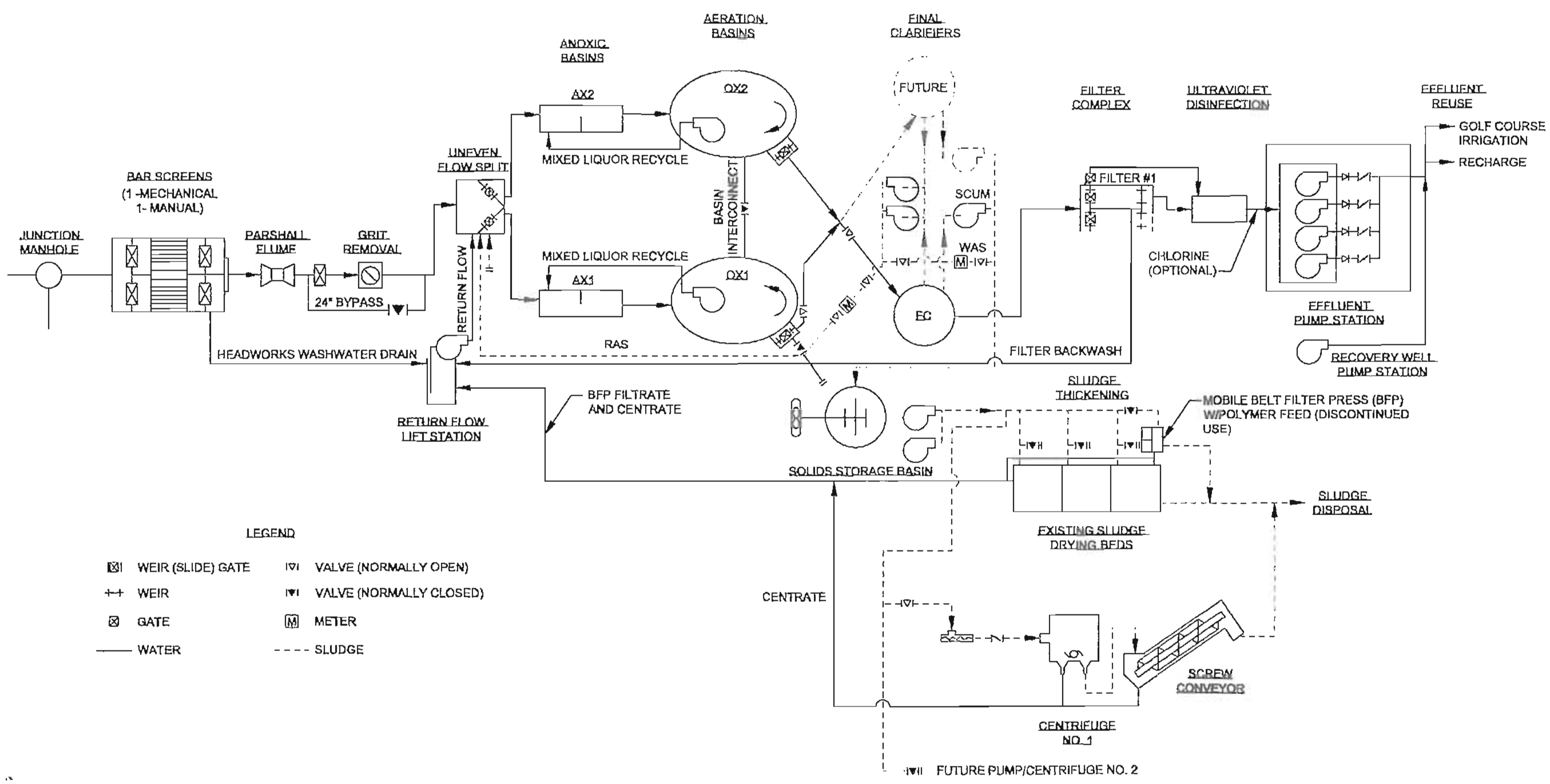
The previous (1998) improvements to the Airport WRF consisted of the following facilities:

- Headworks
  - Mechanical bar screen with manual screen bypass
  - Parshall flume
  - Grit removal (settling basin and grit screw)
- Oxidation Ditches
  - Anoxic basins
  - Modifications to the existing ditch
  - New oxidation ditch
- New Secondary Clarifier
- Sludge Pump Station
- Traveling Bridge Filter
- UV Disinfection

Additional improvements in 2008 included modifications and upgrades to the following facilities:

- Sludge Holding Tank
- Solids Handling (Centrifuge) Building

A process flow schematic of the Airport WRF is shown in Figure 3A.3.



PROCESS FLOW SCHEMATIC

FIGURE 3A.3

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

2.3.1 Headworks

The new headworks replaced the original headworks, and were sized for the ultimate plant capacity of 2.4 mgd (average day) with one mechanical screening unit in service. The headworks consist of one climber-type bar screen, one manually cleaned bar screen to serve as a bypass, a Parshall flume, and a grit removal basin with a grit dewatering screw. The climber screen was covered by an open-sided structure, to reduce icing problems during the winter.

2.3.1.1 Bar Screens

One mechanical "climber" screen was installed for primary duty and one manually cleaned bar screen was installed for emergency bypass flows. Provisions were made for the installation of a second mechanically cleaned bar screen in the future. Screenings are discharged to a front-loading dumpster for landfill disposal. Design criteria for the existing screening facilities is presented in Table 3A.4.

Table 3A.4 Existing Screening Facilities Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Number of Bar Screening Units	
Mechanical	1
Manual	1 (standby)
Clear space between bars, inches	3/4
Channel width, ft	2.6
Channel depth, ft	3.92
Depth of flow, maximum, ft	2.21
Angle of screen inclination, degrees	80
Maximum velocity through screen at 7.2 mgd, fps	3
Average quantity of screenings, cf/day	12
Rake motor horsepower	1.5
Control	Local manual and auto control with repeat cycle timers and head differential override

2.3.1.2 Parshall flume

The installed Parshall flume is capable of measuring the full range of flows expected at the plant. The flume construction is the plastic insert flume liner type. Design criteria for the Parshall flume is presented in Table 3A.5.

Table 3A.5	Existing Parshall Flume Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona
Number	1
Throat width, inches	12
Flow range, mgd	0.07 to 10.41
Level measuring device	Ultrasonic

2.3.1.3 Grit Removal

One grit removal unit was installed, with a grit dewatering screw. The grit chamber was designed to remove 95 percent of 100 mesh grit at peak hour flow. Dewatered grit is discharged from the screw to the front loading dumpster, along with the screenings, for landfill disposal. A slide gate just upstream of the grit removal unit was provided to allow the screened influent flow to bypass the grit removal system, in case it needs to be taken out of service for maintenance or repair. Design criteria for the existing grit removal system is presented in Table 3A.6.

Table 3A.6	Existing Grit Removal System Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona
Number	1
Type	Horizontal flow, square
Grit collection equipment	Circular
Settling rate, fpm	2.4
Nominal depth, ft	1.25
Plan length dimension, ft	10
Grit washer capacity, gpm	100
Grit scraper drive motor horsepower	0.5
Grit dewatering screw motor horsepower	1.0
Average grit removed, cf/day	6

2.3.2 Anoxic Basins, Existing and New Oxidation Ditches

The biological process consists of separate anoxic basins, the original oxidation ditch (Oxidation Ditch No. 2), and a new oxidation ditch (Oxidation Ditch No. 1). The plant operates in the nitrification-denitrification mode.

The anoxic basins consist of a single tank split into two parallel trains, each serving one oxidation ditch. A gate was provided between the two anoxic trains. This allows flow from one side of the process to be fed to the other side. The design criteria for the anoxic basins is presented in Table 3A.7.

Table 3A.7	Anoxic Basins Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona
Number of parallel basins	2
Number of cells per basin	2
Volume per basin, cu. ft.	15,606
Total anoxic basins volume, cu. ft.	31,212
Side water depth, ft	12
Total number of cells	4
Total number of mixers	4
Mixer horsepower, each	3

Oxidation Ditch No. 2 was modified in the 1998 expansion project to allow denitrification, by adding a mixed liquor recycle (MLR) pump to return nitrate-nitrogen to the anoxic basins. After the 1998 expansion project, Oxidation Ditch No. 2 served as a stand-by unit until the service area flows and loads increased enough to require its use on a full-time basis. Oxidation Ditch No. 2 served as a stand-by or as a pretreatment basin for industrial wastewater flows that could upset the microbiology of the process. The diversion of high strength wastewater flows would be accomplished manually. In December 2008, Oxidation Ditch No. 2 was brought back in service to provide sufficient treatment capacity for existing flows, in order to improve the performance of the biological nitrogen removal processes. The design criteria for Oxidation Ditch No. 2 is presented in Table 3A.8.

Table 3A.8	Oxidation Ditch No. 2 (Original) Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona
Design flow rate, mgd [(1)]	1.3
Volume, cu. ft.	93,240
Side water depth, ft	6
Brush Aerators	
Number	3
Peak firm SOTR, pph	200
Motor hp, each	40
MLR Pumps	
Number	1
Type	Submersible centrifugal
Capacity, gpm each	3,800
Rated head, ft	12.5
Motor horsepower	25

Note:

(1) At previous maximum month wastewater concentrations presented in Table 3A.

The newer oxidation ditch (Oxidation Ditch No. 1) and its associated anoxic basin serve as the principal secondary treatment units and were designed for nitrification and denitrification. The design criteria for Oxidation Ditch No. 1 is presented in Table3A.9.

Table 3A.9 Oxidation Ditch No. 1 (New) Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Design flow rate, mgd [(1)]	1.6
Volume, cu. ft.	117,000
Reactor total width, ft	69
Side water depth, ft	12
Straight wall length, ft	146
Total reactor length, ft	215
Brush Aerators	
Number	4
Peak firm SOTR, pph	350
Motor horsepower, each	40
MLR recycle pumps	
Number	1
Type	Submersible centrifugal
Capacity, gpm each	3,800
Rated head, ft.	12.5
Motor horsepower	25

Note:
(1) At previous maximum month wastewater concentrations presented in Table 3A..

2.3.3 Secondary Clarifiers

The 1998 plant expansion design included two new secondary clarifiers. The original clarifier would have served primarily as a sludge thickening tank or as a stand-by clarifier. Due to budgetary constraints, only one of the two secondary clarifiers in the 1998 expansion design was built. The design criteria for the secondary clarifiers is presented in Table 3A.10. Design sludge production based on the 1998 expansion design wastewater flows and loads is presented in Table 3A.10.

Table 3A.10 Secondary Clarifiers Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Original Clarifier	
Diameter, ft	50
Sidewater depth, ft	8
Overflow rate at MMADF, gpd/sq ft	458
Peak solids loading rate, lb/day/sq ft	23
Detention time w/o recycle, hrs	3.1
New Clarifiers	
Number of units in original 1998 expansion design	2
Number of existing units	1
Diameter, ft	60
Sidewater depth, ft	15
Bottom slope	1:12
Overflow rate, MM gpd/sq ft	605
Peak solids loading rate, lb/day/sf	25
Detention time w/o recycle, hrs	4.45
Flocculation well	
Diameter, ft	15
Skirt depth, ft	10
Velocity gradient "G"	50
Motor control	Local manual
Sludge collectors	
Motor control	Local manual with torque overload switch

Table 3A.11 Sludge Production Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Waste Activated Sludge Production	Total	1976 Original Ditch	1998 Expansion Ditch
Average month design flow, mgd	2.4	1.06	1.34
Sludge production, ppd	2,438	1,077	1,361
Sludge production, gpd at 0.5%	58,500	25,800	32,600
Maximum month flow, mgd	2.9	1.3	1.6
Sludge production, ppd	4,094	1,835	2,259
Sludge production, gpd at 0.5%	98,200	44,000	54,200

2.3.3.1 *Sludge Pump Station*

A new sludge pump station was constructed under the 1998 Airport WRF Expansion Project. The 1998 expansion preliminary design included three pumps for return activated sludge (RAS), and two pumps for waste activated sludge (WAS) and scum. However, the 1998 expansion final design (with one new secondary clarifier) included two pumps for RAS and sludge wasting (combined function), and one pump for scum wasting. Due to excessive clogging issues that resulted in inconsistent sludge return rates, City staff replaced the two RAS/WAS pumps with different style units (one in 2006 and one in 2008). The sludge pump station design criteria are presented in Table 3A.12.

Table 3A.12 Sludge Pump Station Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

	1998 Expansion Design	Existing
Return/Waste Activated Sludge Pumps		
Number of pumps	2 (1 duty, 1 standby)	2 (1 duty, 1 standby)
Type	Horizontal end suction, non-clog centrifugal	Submersible, open bottom, non-clog centrifugal (Flygt, type “N” impeller)
Rated capacity, gpm each	1,000	444 (1)
Rated head, ft	35	21.3 (1)
Motor horsepower	15	5
Motor control	Variable frequency drives	One unit with variable frequency drive. One unit constant speed.
Scum pump		
Number of pumps	1	
Type	Horizontal end suction, centrifugal non clog	
Rated capacity, gpm	100	
Rated head, ft	40	
Control	Timer, local manual, auto level	

Note:
(1) Based on duty point in pump curve provided by plant staff.

2.3.4 Filtration

Filtration facilities in the original 1998 expansion design were designed to meet the maximum month flow. A by-pass was provided for peak hour flow and for removal of the filters from service. The filters are the traveling bridge, continuous backwash type. Due to budgetary constraints, one filter was deleted from the original 1998 expansion design project. Using typical hydraulic loading rates, the average and peak flow capacities of the existing filter are 1.5 and 3.0 mgd, respectively. The tertiary filters design criteria is presented in Table 3A.13.

Table 3A.13 Tertiary Filters Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona		
	1998 Expansion Design	**Existing**
Type	Traveling Bridge	
Number	2	1
Total filtration area, sq ft	850	525
Average day flow capacity at hydraulic loading rate of 2.0 gpm/sq ft	2.4	1.5
Peak flow capacity at hydraulic loading rate of 4.0 gpm/sq ft	4.9	3.0
Media type	Sand, 0.5 mm Anthracite, 0.9 mm	Sand, 0.5 mm
Media depth	12 in. sand 12 in. anthracite	15 in. sand

2.3.5 Disinfection System

A new disinfection system was installed under the 1998 Airport WRF Expansion, which utilized low pressure ultraviolet disinfection (UV) technology. The UV system in the 1998 expansion design was originally sized for an initial peak flow of 4.8 mgd, expandable to 7.2 mgd. The existing low pressure UV system is sized for an initial peak flow of 3.6 mgd, expandable to 7.2 mgd. The existing chlorine feed system was expanded/upgraded to meet increased flows to provide a residual in the reuse transmission main. The UV disinfection system design criteria are presented in Table 3A.14.

A gas chlorination system is located in the building adjacent to the UV disinfection system. Chlorine can be dosed to the disinfection channels. The chlorination system is seldom used at the plant. Gas chlorine cylinders (100 pounds) are stored in the chlorine building. The chlorination system (Bailey, Fischer and Porter) doses chlorine using an eductor that feeds the carrier water line.

Table 3A.14 Ultraviolet Disinfection System Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona	
	Existing
Number of channels	1 (initial) 2 (ultimate)
Channel dimensions, L x W x D, feet	16.8 x 2.08 x 8
Depth of flow, ft	5.2
Peak design flow per channel, mgd	3.6 (initial) 7.2 (ultimate)

Table 3A.14 Ultraviolet Disinfection System Design Criteria Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona	
	Existing
Percent UV transmission	65
UV system manufacturer	Ultratech
Number of modules	4
Number of UV lamps	160 (initial) 320 (ultimate)
UV intensity, watts per gallon	13.6
Minimum UV dose at peak flow, uW-s/cm^2	30,000
Suspended solids / BOD, mg/L	
Monthly average	5 / 5
Maximum daily	30 / 30
Effluent Fecal Coliform, CFU/100 mL	
30-day geometric mean	<25
Single-sample maximum	<75
Water temperature range, degrees Celsius	13 - 23

2.3.6 Effluent Pump Station

No modifications to the existing effluent pump station were made during the 1998 expansion project. Disinfected water from the UV channel flows by gravity into a wet well. The existing effluent pump station is located adjacent to the wet well. The existing effluent pumps are installed in a dry pit configuration, and the pumps are connected to a common discharge header.

Non-potable water (NPW) pumps for in-plant water uses are located in the upper level of the existing effluent pump station. The suction side of the NPW pumps is connected to the discharge header of the effluent pumps, and is not directly connected to the effluent wet well. The Recovery Well Pump Station is located northeast from the effluent pump station, and its main purpose is to pump water to the effluent line going to a golf course irrigation system. The Recovery Well Pump Station is operated on an as-needed basis during seasons of high water demand from the golf course.

Table 3A.15 Effluent Pump Station Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Effluent Pumps	
Number of units	3
Flow capacity, gpm	800 (2 units) 500-600 (1 unit) [(1)]
Motor horsepower, each	40
Non-Potable Water Pumps	
Number of units	2
Flow capacity, gpm	60 (one unit) One unit - unknown
Motor horsepower, each	1 @ 3 1 @ 10
Recovery Well Pump	
Number of units	1
Flow capacity, gpm	700 [(1)]
Motor horsepower, each	250

Note:
(1) Pump curve not available. Capacity estimated based on plant staff experience.

2.3.7 Solids Handling

A City-owned, trailer-mounted belt dewatering press was installed near the existing sludge drying beds after the 1998 expansion project. All chemical feed required was also mounted on the trailer. Feed sludge was pumped to the dewatering press using the RAS pumps. Piping and electrical modifications were made to accommodate the installation. Operation of the trailer-mounted belt dewatering press was discontinued in April 2009.

New solids handling facilities were added to the Airport WRF as part of the Centrifuge Building and Equipment Installation Project in 2009. Sludge dewatering operations with the new solids handling facilities began in April 2009. The older secondary clarification basin was converted into an aerated solids holding tank, and a new building was added to the plant facilities, which includes a dewatering centrifuge and its associated equipment.

The current solids handling practice is dewatering undigested sludge, followed by landfill disposal. WAS is continuously pumped to the aerated solids holding tank. The solids in the holding tank are aerated and mixed. To achieve additional thickening of the WAS, aeration is stopped for short periods to allow solids settling. Decant from the settling operation in the solids holding tank is sent back to the head of the anoxic basins. The thickened WAS is sent to the centrifuge building for dewatering and subsequent disposal via a roll-off bin.

2.3.7.1 Solids Holding Tank

The secondary clarifier built in the initial phase of the Airport WRF (1976 project) has been converted into a solids holding tank, by removing the secondary clarification mechanism and performing several modifications. WAS is continuously pumped into the solids holding tank over the course of the day using the RAS pumps and a flow control valve. Aeration and mixing is provided with a coarse bubble diffuser system and a positive displacement blower. Submersible pumps in the solids holding basins are used to pressurize the WAS line connected to the centrifuge feed pumps located in the centrifuge building. The solids holding tank description is summarized in Table 3A.16.

Table 3A.16 Solids Holding Tank Description
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Tank dimensions	
Tank diameter, feet	50
Side water depth, feet	Variable up to 8
Aeration system	
Number of blower units	1
Motor horsepower	20
Diffuser type	Coarse bubble, 2 ft units
Number of diffusers	56
Thickened WAS pumps	
Pump type	Submersible, open bottom, non-clog centrifugal (Flygt, type “N” impeller)
Number of units	2
Capacity, gpm	333 (1)
Rated head, ft	12.8 (1)
Motor control	One unit with variable frequency drive. One unit constant speed.
Motor horsepower, each	3

Note:
(1) Based on duty point in pump curve provided by plant staff.

2.3.7.2 Centrifuge Building

A new centrifuge building was constructed in April 2009, and is located at the southeast end of the existing plant site. The centrifuge building includes one dewatering centrifuge, with its associated sludge grinder, feed pump, and polymer feed system. Provisions have been made for the installation of a second dewatering centrifuge unit and its associated equipment. The design criteria for the existing dewatering system is summarized in Table 3A.7.

Table 3A.17 Dewatering Centrifuge System Design Criteria
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Dewatering centrifuge	
Manufacturer	Centrisys
Number of units	1 (1)
Hydraulic loading capacity, gpm	50 to 70 (2)
Feed solids concentration, percent	0.6 to 2.5 (average: 1.0)
Maximum solids loading capacity, lbs/hr	575
Minimum solids capture, percent	95
Minimum cake solids content, percent	20
Motor horsepower, main drive	30
Motor horsepower, back drive	10
Sludge grinder	
Type	In-line (Boerger)
Number of units	1 (1)
Capacity, gpm	70
Motor horsepower	5
Centrifuge feed pump	
Pump type	Progressive cavity (Netzch)
Number of units	1 (1)
Capacity, gpm	70
Discharge pressure, psi	100
Suction pressure	Flooded
Maximum solids concentration, percent	12
Motor horsepower	7.5
Polymer feed system	
Type	Liquid polymer blending system (Velodyne)
Number of units	1 (1)
Neat polymer metering pump	Progressive cavity, 1 to 10 gph
Dilution water inlet	1 to 10 gpm
Polymer mixing chamber	Staged hydrodynamic (non-mechanical)

Notes:
(1) Provisions in existing building allow 2 units to be installed.
(2) At feed solids (WAS) concentrations between 0.6 and 2.5 percent solids. Excludes polymer flow.

2.3.8 Return Flow Lift Station

The Return Flow Lift Station receives drain flow from the following five locations.

- UV wash water drain;
- Sludge drying bed drains;
- Filter backwash;
- Filtrate and wash water from portable belt filter press (discontinued use since April 2009);
- Centrate and wash water from the Centrifuge Building.

The return flow is pumped to the head of the BNR activated sludge process, at the anoxic zones splitter structure. The pump station contains two submersible pumps each rated at 540 gpm at 20 feet of head. Under normal operating conditions, one pump was designed to be a standby unit. The pumps are automatically operated based on four float switches in the wet well.

2.3.9 Standby Power

A 150 kW diesel engine powered generator provides emergency power for selected plant equipment. The generator powers the headworks, one oxidation ditch rotor, the clarifier drive, effluent pump, UV system, and one RAS pump.

There is currently no natural gas service to the site.

2.4 Existing Facility Permits

The Airport WRF was designed and permitted to produce Class B+ effluent, and the Aquifer Protection Permit (APP) that has been recently revised and issued by ADEQ is structured for Class B+ effluent. The existing facility design, however, has been structured around the ability to produce Class A+ in the future, should permit requirements ever become more stringent. Moving forward, process evaluation will be based on technologies capable of producing ADEQ Class A+ reclaimed water. These water quality standards are shown in Table 3A.18.

Table 3A.18 ADEQ Reclaimed Water Quality Standards
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Parameter	Class A+ Standards	Class B+ Standards
Total Nitrogen, mg/L		
Maximum limit	10	10
Alert level	8	8
Turbidity, NTU		
Average	2	N.A.
Single Sample Maximum	5	N.A.
Fecal Coliform, cfu/100 mL		
4 of last 7 samples	Non-detect	200
Single Sample Maximum	23	800

3.0 PHYSICAL CONDITIONS

3.1 Site Survey

The coordinate system for the Airport WRF site during the 1998 expansion project used the Arizona State Plane coordinate system. Specific coordinates to be used for horizontal control were listed on the 1998 plans prepared by Black & Veatch.

The 1998 expansion project benchmark was based upon benchmark H-262, which was reset in 1981. The benchmark is located near the west side of the Ernest A. Love Field Airport Terminal Building. The benchmark elevation was 5011.88.

Future horizontal and vertical control will fall under the City of Prescott Layer and Survey Datum Requirements, as outlined in Appendix B herein.

3.2 Geotechnical Conditions

A geotechnical site investigation was performed in 1996 by Engineering and Testing Consultants (ETC), Inc. A copy of the original report has not yet been received by Carollo Engineers, however, the 1996 Black & Veatch preliminary design report indicates the following geotechnical information:

3.2.1 Spread Foundations

Spread Foundations bearing on approved undisturbed soils may be designed for an allowable bearing pressure of 4,000 psf. Allowable bearing pressure may be increased 33% for wind or seismic design. Bearing to be 24-inches below finished exterior grade, or 12-inches below finished floor or finished interior grade. Minimum footing size to be 24-inches for isolated footings and 16-inches for continuous footings.

3.2.2 Consolidation

ETC considered the bearing strata to be unyielding with negligible consolidation settlements. Strain settlements were anticipated to be 1/2-inch, all of which should occur during construction. A subgrade modulus value of 300 lbs/in^3 was recommended.

3.2.3 Ground Water

No ground water was encountered in any of the nine borings drilled to elevation 4,900+/-. The soils report stated that “wells drilled within a 1-1/2 mile radius of the site indicate depth to ground water at an average of elevation 4,610,” which is approximately 300 feet below the lowest level of existing structures. Therefore, ground water and/or floatation was not considered in the design of any of the structures. It should be noted that the original report by ETC does not reflect current recharge levels as of 2009. Plant staff reports short-term mounding due to the existing recharge performed at the Airport WRF recharge basins.

3.2.4 Excavation Slope

A maximum of 2:1 horizontal to vertical slope was recommended. The footings rising from deeper portions of the foundations were required to follow this inclination, either as a continuous slope, or in equivalent steps.

3.2.5 Lateral Earth Pressure

Table 3A.19 indicates the parameters that were used in the design for lateral earth pressure.

Table 3A.19 Previously Defined Geotechnical Parameters - Lateral Earth Pressure
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Parameter	Design Value
Lateral Backfill Pressure	
Unrestrained Walls	40 psf/ft
Restrained Walls	60 psf/ft
Lateral Passive Pressure	
Continuous Walls/Footings	250 psf/ft
Isolated Columns/Footings	350 psf/ft
Coefficient of Base Friction	
Independent of Passive Resistance	0.50
In Conjunction with Passive Resistance	0.30

It is anticipated that geotechnical conditions will be updated/verified under this contract in the near future, and that a new geotechnical report will be generated prior to any future detailed design.

3.3 Physical Condition Assessment

A visual inspection of the major equipment and structures at the Airport WRF was conducted as part of this project. The intent of the inspection was to document the general condition of all major equipment and structures at the plant, to provide input for future improvements planning. The structural inspections were limited to the interior surfaces of walls above the waterline. Similarly, mechanical inspections were limited to equipment components above the waterline. This visual inspection did not include functional tests, core sampling, or other detailed tests, and was limited to a general visual assessment of the condition of equipment and structures at the WRF.

A three-grade rating system was used to evaluate equipment and structures. Structures were rated as “good” when there were no visible signs of concrete deterioration or other apparent issues with the integrity of the concrete. Structures were rated as “fair” when there were some signs of concrete deterioration, such as minor spalling or cracks. Structures were rated as “poor” if severe signs of concrete deterioration were found, such as exposed rebar, extensive corrosion, or major spalling and cracks.

Equipment was rated as “good” when there were no visible signs of deterioration needing immediate attention. Equipment was rated as “fair” when there were minor deficiencies that require attention. A “poor” rating implies that immediate action is required to correct an evident mechanical problem.

The visual condition assessment of the major equipment and structures at the plant is summarized in Table 3A.20. In general, most of the facilities at the Airport WRF can be considered in relatively good condition, with a few unit processes needing attention to resolve minor issues.

Table 3A.20 Condition Assessment of Existing Facilities
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Unit Process	Structure Condition	Equipment Condition
Headworks		
Mechanical bar screen	Good	Good
Manual bar screen	Good	Good
Grit removal	Good	Good
Activated Sludge System		
Anoxic basins	Good	Good
Oxidation Ditch No. 1 (1998)	Good	Good
Oxidation Ditch No. 2 (1976)	Fair (1)	Fair (1)
Secondary clarifier	Good	Good
Tertiary filter	Good	Good (2)
UV Disinfection	Good	Good
Effluent and NPW Pumping		
Pump station / Wet well	Good	Good
Recovery Well Pump Station	Good	Good
Solids Handling		
Solids Holding Tank	Fair (3)	Good
Dewatering system	Good	Good

Table 3A.20	Condition Assessment of Existing Facilities Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott, Arizona		
	Unit Process	**Structure Condition**	**Equipment Condition**

Notes:

(1) Minor cracks and concrete spalling were observed. The shotcrete thickness is 2.5 inches per the record drawings. Brush rotors showed some evidence of corrosion, and a few missing blades. Plant staff has recently performed maintenance on the equipment and equipment is in operation.

(2) Media replacement was performed in 2007. Plant staff reported that the filter underdrain system was in good condition at the time that the media was replaced.

(3) Minor cracks and concrete spalling were observed.

4.0 CAPACITY ANALYSIS

A process model was used to evaluate the treatment capacity of the Airport WRF. The process model simulates the plant performance based on inputs for flow, loading, and other operating conditions. Outputs from the model are process effluent characteristics, process safety factors on achieving given criteria, or the allowable loading to prevent process failure.

The primary objective for modeling the performance of the Airport WRF was to evaluate the performance of the existing facilities under current and future loadings, in order to determine the treatment capacity of the existing facilities.

The approach used for the process modeling effort included the following steps:

- Establish design influent wastewater flows and characteristics to be used for the process evaluation under existing conditions.
- Customize and calibrate the process model for the Airport WRF under existing conditions.
- Using the calibrated process model, evaluate the performance of the secondary treatment process under existing and future conditions, under the design wastewater flows and loadings.

4.1 Wastewater Flows

Daily average, high, and low influent flows were obtained from plant operational data records between January 2006 and April 2009. The average daily flow into the plant has been consistently increasing over time. Throughout a calendar year, the plant typically receives higher flows during winter months, probably due to infiltration during wet weather months. A chart with the historical flow data analysis and the recommended flow peaking factors is presented in Figure 3A.4. The highest flow reported (January 8, 2008) corresponded to a wet weather event, but the flow value was above the maximum flow of the flow recorder scale. The highest peak flows have historically occurred during winter months (December to February), although peak flows during summer months (July to August) are also significant.

The recommended maximum month flow peaking factor was based on the ratio between the maximum 30-day running average flow and the annual average day flow. Due to the gradual consistent increase of the annual average day flow, a linear regression was used to calculate the annual average flow over the entire period of data analysis. The peak day factor was based on the ratio between the maximum daily average flow and the annual average flow. The peak hour factor was based on the ratio between the maximum high flow reported and the annual average day flow. The recommended peaking factors are presented in Table 3A.21. The recommended peaking factors are similar to values observed in typical domestic wastewater treatment facilities in Arizona.

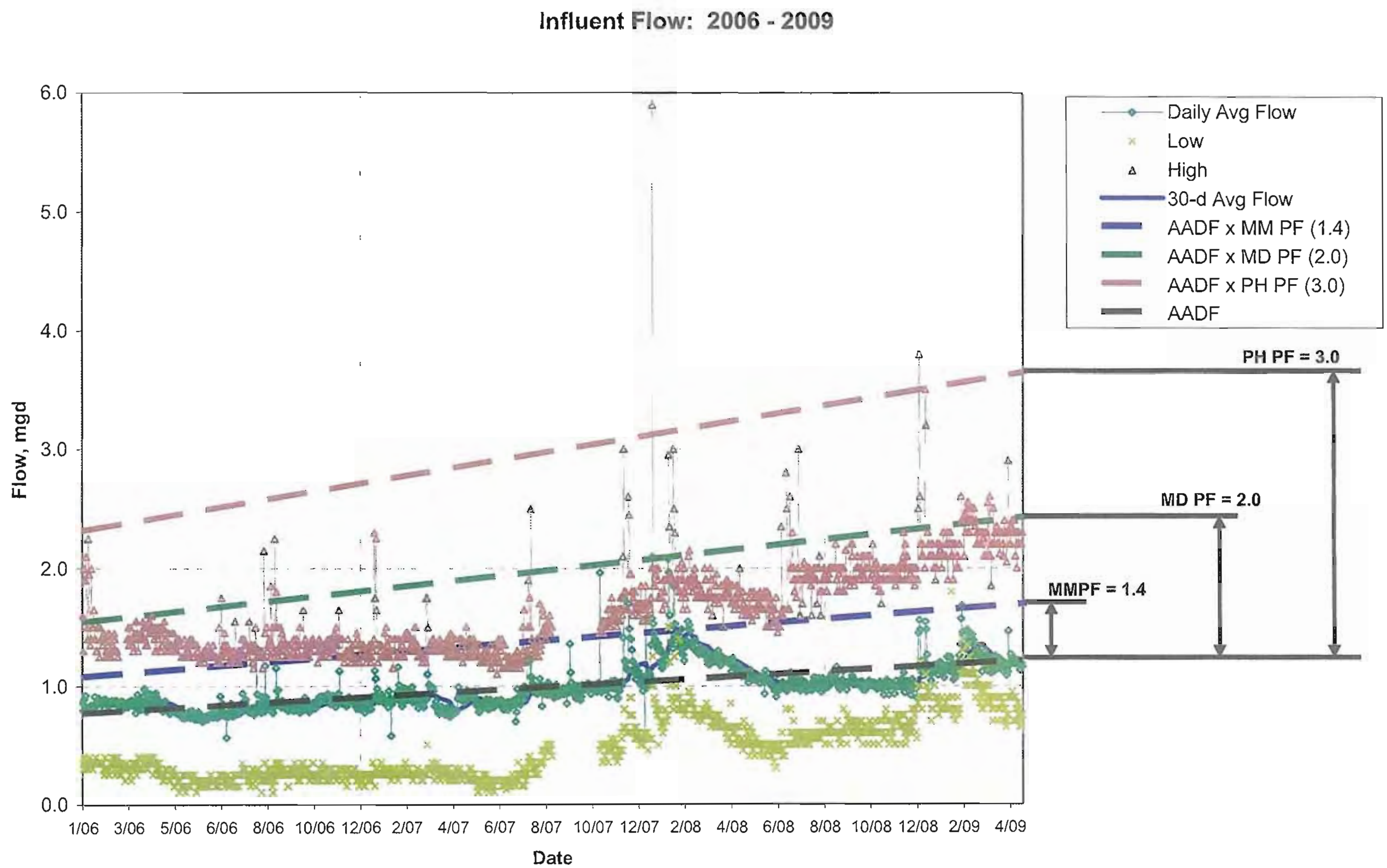
Table 3A.26 Design Hydraulic Peaking Factors
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Hydraulic Peaking Factor [1]	Value
Maximum Month Average Day	1.4
Peak Day	2.0
Peak Hour	3.0

Note:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

4.2 Wastewater Characteristics

The wastewater characteristics for the plant capacity analysis were determined based on an analysis of the plant's historical wastewater quality records. Influent characteristics were obtained from plant operations historical records between 2006 and 2009. Composite samples of the plant influent are taken at the headworks, after the wastewater goes through screening and grit removal. Flow and characteristics from the tertiary filter backwash stream and sludge dewatering equipment are not routinely measured, but are included in the influent wastewater quality characteristics.



INFLUENT FLOWS AND PEAKING FACTOR ANALYSIS

FIGURE 3A.4

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 3A - AIRPORT WRF EXISTING CONDITIONS

The following wastewater quality data provided by the City was used in the analysis:

- **Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS):** Approximately four samples per month (one per week). Data was analyzed for the period between January 2006 and April 2009.
- **Total Kjeldahl Nitrogen (TKN) and Ammonia Nitrogen (N):** One sample per month between May 2006 and June 2008.

The raw data set included unusually high values of influent BOD and TSS. Therefore, a statistical approach was used to filter the data set and eliminate extreme values, both at the high end and low end of the observed ranges. "Filtered" ranges for BOD and TSS concentrations were defined by the respective average values plus and minus two times the standard deviation based on the raw data set. Data points falling outside the "filtered" ranges were excluded from the analysis. Six BOD concentrations and three TSS concentrations were excluded from the analysis using this data filtering approach. The filtered data set was then used for the calculation of all the averages and percentiles reported herein.

Table 3A.22 presents the average influent wastewater characteristics per year over the analysis period. Graphs of influent wastewater concentrations and calculated loadings are included in Appendix A.

Table 3A.22 Average Influent Wastewater Characteristics
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott, Arizona

Parameter	2006	2007	2008	2009 (1)	2006-2009
BOD, mg/L	346	283	349	271	322
TSS, mg/L	427	505	579	475	504
TKN, mg/L	32.4 (2)	28.1	50.6 (3)	N.A.	34.6 (4)
Ammonia N, mg/L	30.7 (2)	26.6	33.8 (3)	N.A.	29.5 (4)

Notes:
(1) From January to April, 2009
(2) From May to December, 2006
(3) From January to June, 2008
(4) From May 2006 to June 2008

The recommended wastewater characteristics for design and capacity evaluation purposes were based on determining wastewater concentrations under annual average day loadings and maximum month average day loadings. Average loadings were based on average wastewater concentrations calculated over the entire analysis period (2006 to 2009).

The recommended wastewater characteristics for maximum month loadings were based on a statistical analysis of the reported wastewater quality. The maximum month load peaking factors were calculated based on the ratio between the 92nd percentile of all reported wastewater concentrations in the analysis period (2006 to 2009) and the average wastewater concentrations. The 92nd percentile values were selected as representative values for maximum month conditions, based on the assumption that 8 percent of the time (1 in 12 months) in a year is the maximum month. Table 3A.23 presents the recommended maximum load peaking factors for design and capacity analysis purposes.

The dynamics of flows and loads in the plant influent show that maximum month wastewater loads (pounds per day) typically coincide with maximum month flows. Therefore, the recommended wastewater concentrations at maximum month conditions represent the combination of maximum month flow and wastewater concentrations that result from the recommended maximum month load peaking factors.

Table 3A.23 Influent Loading Peaking Factors
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott

Parameter	Average (1)	92nd Percentile (1)	Recommended Maximum Month Load Peaking Factor
BOD, mg/L	322	537	1.67
TSS, mg/L	504	886	1.76
TKN, mg/L	34.6	51.7	1.67 (2)
Ammonia, mg/L	29.5	34.8	1.67 (3)

Notes:
(1) Based on historical data between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.
(2) The calculated peaking factor is 1.49. The recommended peaking factor is equal to the BOD load peaking factor for a conservative design/capacity analysis of the denitrification process.
(3) The calculated peaking factor is 1.18. The recommended peaking factor is equal to the BOD load peaking factor for a conservative design/capacity analysis of the denitrification process.

Temperature for design and capacity evaluation purposes was based on the plant-reported values sampled from the mixed liquor, which is a direct measure of the process temperature. Process temperature is a critical parameter for the design and capacity evaluation of the secondary treatment system. Maximum month loadings occur during winter months, which is also the period of slower biological activity due to the lower process temperatures. Therefore, maximum month loading conditions under winter temperatures represent the most critical conditions for the secondary system.

Table 3A.24 presents the recommended wastewater characteristics at average and maximum month conditions, used for the capacity evaluation presented herein.

Table 3A.24 Design Wastewater Concentrations Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott			
Parameter	**Unit**	**Annual Average Day**	**Maximum Month Average Day [1]**
Design Concentrations			
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity [1]	mg/L	250	250
Temperature [2]	°C	18.4	12.4
pH	--	7.3	7.3

Notes:
(1) Assumed. No data available.
(2) Based on mixed liquor temperature measurements.
(3) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).

4.2.1 Influent Wastewater Characteristics Discussion

The average BOD concentration for the Airport WRF is within the typical range of values observed for other facilities in Arizona. However, there are several reported BOD concentrations in the 600 to 800 mg/L range, mostly during the winter of 2006-2007. These values are relatively high compared to typical values observed in domestic wastewater.

The reported TKN and ammonia values are within typical values for domestic wastewater in Arizona. An increasing trend in TKN and ammonia concentrations was noted since September of 2007. We recommend monitoring the influent TKN and ammonia as frequently as BOD and TSS in the future.

The average and maximum month influent TSS are relatively high compared to other facilities in Arizona. The observed average TSS to BOD ratio of 1.5 is relatively high, compared to a more typical ratio of 1.2. The original design BOD to TSS ratio was 1.36. Some of the reported influent TSS values are unusually high, in the 1,000 to 1,400 mg/L range.

The existing wastewater concentrations are significantly higher than the criteria used for the original design of the secondary treatment facilities. Table 3A.25 summarizes the comparison between the original design criteria and existing conditions, as it pertains to influent wastewater concentrations. The existing BOD and TSS wastewater concentrations are higher than the original design criteria values by factors ranging between 2.6 and 3.2. The existing average TKN concentrations are similar to the values used for the original design.

Table 3A.25 Original Design and Existing Conditions Influent Wastewater Concentrations Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott				
Parameter	**Unit**	**Original Design Criteria**	**Existing Conditions Criteria (1)**	**Existing / Original**
BOD, Annual Average	mg/L	117	322	2.75
BOD, Maximum Month	mg/L	155	383	2.47
TSS, Annual Average	mg/L	159	504	3.17
TSS, Maximum Month	mg/L	211	633	3.00
TKN, Annual Average	mg/L	35	34.6	0.99
TKN, Maximum Month	mg/L	36	41.2	1.15

Note:
(1) Based on historical data between January 2006 and April 2009.

Table 3A.26 summarizes the comparison between original design and existing conditions, as it pertains to influent wastewater mass loadings. Mass loadings ultimately determine the loadings to the secondary system, and they are the product of flow and concentration. The influent hydraulic flows are well below the original buildout design values. However, the BOD and TSS mass loadings are between 18 and 49 percent higher than the original design values.

Table 3A.26 Original Design and Existing Conditions Wastewater Mass Loadings Technical Memorandum No. 3A - Airport WRF Existing Conditions City of Prescott				
Parameter	**Unit**	**Original Design Criteria**	**Existing Conditions Criteria (1)**	**Existing / Original**
Flow, Annual Average	mgd	2.4	0.99	0.41
Flow, Maximum Month	mgd	2.9	1.39	0.48
BOD, Annual Average	ppd	2,340	2,636	1.13
BOD, Maximum Month	ppd	3,750	4,396	1.17
TSS, Annual Average	ppd	3,190	4,219	1.32
TSS, Maximum Month	ppd	5,103	7,423	1.45
TKN, Annual Average	ppd	697	287	0.41
TKN, Maximum Month	ppd	871	478	0.55

Note:
(1) Based on historical data between January 2006 and April 2009.

4.2.1.1 Alternative Maximum Month Concentrations

An alternative approach commonly used to determine maximum month concentrations is to use the 85th percentile of all the concentrations in the data set, instead of the 92nd percentile as used in this analysis. A comparison between using 85th percentile versus 92nd percentile concentrations is summarized in Table 3A. 27.

Using the 85th percentile instead of the 92nd percentile values results in lower design maximum month concentrations, by approximately 13 percent. Due to the relatively small reduction in wastewater concentrations with the alternative approach, the consensus was to use 92nd percentile values to determine maximum month concentrations. The 92nd percentile approach provides a conservative estimate of maximum month conditions, and was considered adequate for the purposes of this study.

Table 3A.77 Maximum Month Wastewater Concentrations Comparison
Technical Memorandum No. 3A - Airport WRF Existing Conditions
City of Prescott

Parameter	Unit	Maximum Month Average Day 92nd percentile (1)	Maximum Month Average Day 85th percentile (1)	Difference (2)
Design Concentrations				
BOD	mg/L	383	333	- 13%
TSS	mg/L	633	548	- 13%
TKN	mg/L	41.2	35.8	- 13%
Ammonia N	mg/L	35.1	30.5	- 13%

Notes:
(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).
(2) Difference with respect to 92nd percentile concentrations.

4.2.1.2 Additional Wastewater Characterization

Additional sampling upstream of the WRF was recommended in order to identify any possible sources of unusually high TSS loadings. Wastewater samples were collected at several points in the collection system in the vicinity of the Airport WRF. Locations that were sampled on two different days showed a wide variation in BOD and TSS concentrations. BOD and TSS values at the plant headworks agreed with historical values.

Additional testing parameters for the influent wastewater at the plant was also recommended as part of this study. These additional testing parameters allowed a more detailed characterization of the different fractions (e.g., soluble, colloidal, particulate) of BOD, COD, nitrogen, and phosphorus, as well as inert TSS in the influent wastewater. These fractions were used to confirm assumptions made during process model calibration in regards to the wastewater fractionation parameters. The additional sampling also corroborated the relatively high BOD and TSS values observed in the long-term data set. The results of the detailed wastewater sampling efforts are included in Appendix C.

4.3 Process Modeling

Process modeling for the Airport WRF was performed using the Biological Treatment Analysis (Biotran) modeling program. Biotran is a modeling tool developed by Carollo Engineers for wastewater treatment plant design and process evaluations. This program utilizes mass balances, and biological and physical models, to simulate interactions between the different unit processes in a wastewater treatment facility. The model is used in conjunction with the wastewater characteristics and design criteria to establish treatment capacities for the different processes. The model also generates projections for biosolids production, oxygen utilization, etc., that can be used to size auxiliary facilities (i.e., blowers, pumps, etc.).

Biotran is a steady state model. Therefore, the model predictions represent average values and not individual values taken at a particular time of the day. In reality, plant flows, concentrations and operating conditions vary during the course of the day, and from week to week. As a result, projections from a steady-state model, as shown here, must not be expected to accurately replicate individual samples taken on any particular day. However, model predictions can be compared to averages of concentrations observed over a period of time for which the evaluation is being performed.

4.3.1 Model Calibration

The Biotran process model was customized to simulate the existing unit processes at the Airport WRF. Basin dimensions, flow routing, and equipment capacities were based on the 1998 Expansion drawings, the facility Operations and Maintenance (O&M) Manual, and discussions with plant staff during plant visits.

The approach used for model calibration was to incorporate the available plant data as inputs to the model, and compare the steady state model predictions with annual averages of plant operating data. The annual average influent BOD, TSS, TKN, and ammonia values were used as inputs for the model calibration. Graphs of process data used in the model calibration procedure are included in Appendix A.

The model predictions were in relatively good agreement with the plant data. The model was calibrated to match the values predicted by the model to the actual reported average values of ammonia, nitrate and nitrite concentration in the effluent, as well as solids production in the waste activated sludge (WAS) stream. The main inputs used in the model calibration procedure are specific parameters that define the different components of domestic wastewater, in addition to input parameters based on actual data such as influent BOD, TSS, TKN and ammonia. Wastewater is composed of biodegradable, unbiodegradable, and inorganic fractions, and each of these fractions is further subdivided into soluble and particulate components. Each of these specific parameters affects the predicted performance of the biological system in a particular manner. For example, effluent nitrate levels are very dependent on the amount of soluble biodegradable matter (i.e., soluble BOD) in the anoxic zones of the system. Sludge production is influenced not only by the amount of bacterial growth, but also by the unbiodegradable particulate fraction of the influent TSS. The specific parameters that determine the biodegradable, unbiodegradable, and inorganic fractions of soluble and particulate components were calibrated within typical ranges of values normally observed in domestic wastewater. The unbiodegradable particulate fraction of the influent TSS, however, was relatively low compared to typical values.

4.3.2 Evaluation Criteria

The overall plant capacity is determined by the capacity of the individual unit processes. For some unit processes, the capacity is based on the hydraulic peak flows. Under this category are the headworks equipment and the tertiary treatment facilities. In this evaluation, the maximum rated capacity of unit processes governed by hydraulic flow was compared to peak daily or peak hourly flows to determine possible limitations in the overall treatment process capacity. The wastewater flows (annual average day, maximum month average day, peak day, peak hour) used for this evaluation were presented in Table 3A..

The capacity of the secondary process, however, is based not only on flow, but also on the influent wastewater characteristics, and on operating parameters such as solids retention time (SRT), mixed liquor suspended solids (MLSS) and sludge settleability characteristics. The secondary process includes the aeration basins, aeration system, secondary sedimentation basins, as well as mixed liquor return (MLR) and return activated sludge (RAS) pumps.

To determine the secondary process treatment capacity, the activated sludge treatment facilities were evaluated based on their capacity to operate effectively at different design influent flow and loadings. The process modeling approach was to allow the secondary clarifier overflow rate and solids loading safety factor to determine the maximum acceptable operating mixed liquor suspended solids (MLSS) concentration in the aeration basins. The resulting MLSS results in a given solids retention time (SRT) of the secondary system, which was evaluated together with the effluent characteristics to determine whether the predicted performance of the secondary system would be acceptable to meet the effluent quality criteria.

The main requirement in the selection of a minimum required SRT is that the operating aerobic SRT must be long enough to support stable nitrification throughout the year. A recommended minimum aerobic SRT is calculated in the Biotran model as a guideline for ensuring stable nitrification. The evaluations presented in this technical memorandum were based on achieving a minimum aerobic SRT of approximately 8 days. A shorter aerobic SRT compromises the ability of the plant to successfully perform nitrogen removal, especially under winter conditions.

A minimum clarifier safety factor (CSF) of 2.0 was selected for this analysis. The CSF is defined as the ratio between the maximum settling velocity of the mixed liquor and the basin overflow rate. Therefore, the purpose of maintaining a clarifier safety factor of 2.0 under average day flow conditions is to prevent solids carryover in the effluent from the secondary clarifiers.

Effluent characteristics are another important criteria in determining the capacity of the secondary process. The governing criterion for this analysis was the effluent total nitrogen (TN), which is the sum of ammonia (NH_3-N), nitrate (NO_3-N), nitrite (NO_2-N), and organic nitrogen. In the capacity evaluations reported in this technical memorandum, a maximum total inorganic nitrogen (TIN) concentration of approximately 6 mg/L was selected. TIN includes ammonia, nitrate and nitrite nitrogen. This criterion allows the organic nitrogen concentration to be about 2 mg/L before the effluent TN reaches the alert level of 8 mg/L, as identified by the plant's Aquifer Protection Permit, which also stipulates a TN limit of 10 mg/L. Both of these TN limits are based on a five-sample rolling geometric mean. Plant records for 2006-2009 indicated that the average effluent organic nitrogen concentration was approximately 1.2 mg/L.

In addition to the TN criterion, maximum effluent ammonia and nitrite concentrations of approximately 2.0 and 1.0 mg/L, respectively, were used for the evaluation. These concentrations are mainly controlled by the extent of nitrification in the system. The most critical conditions are maximum month loadings during winter conditions, which result in decreased aerobic SRT values that make nitrification during winter months the controlling factor.

4.3.3 Capacity Analysis Estimate

The capacity of each process unit was evaluated by comparing its maximum capacity to the appropriate governing criterion. As discussed before, the plant capacity was evaluated under maximum month flow and loading conditions, although several process units were evaluated at either peak day or peak hourly flows. The estimated capacity of each process unit was expressed in terms of average day flow using the appropriate peaking factors.

4.3.3.1 Preliminary Treatment

The mechanical screen and grit removal units at the headworks facilities have a rated peak flow capacity of 7.2 mgd each, which results in an average day capacity of 2.4 mgd (peaking factor of 3.0) based on the information given in the O&M Manual and the design report. The single existing bar screen capacity is based on a maximum clear velocity of 3 feet per second (fps) at the maximum water level. The bypass manual screen has been sized with the same criteria and therefore has the same capacity as the mechanical bar screen.

4.3.3.2 Secondary Treatment

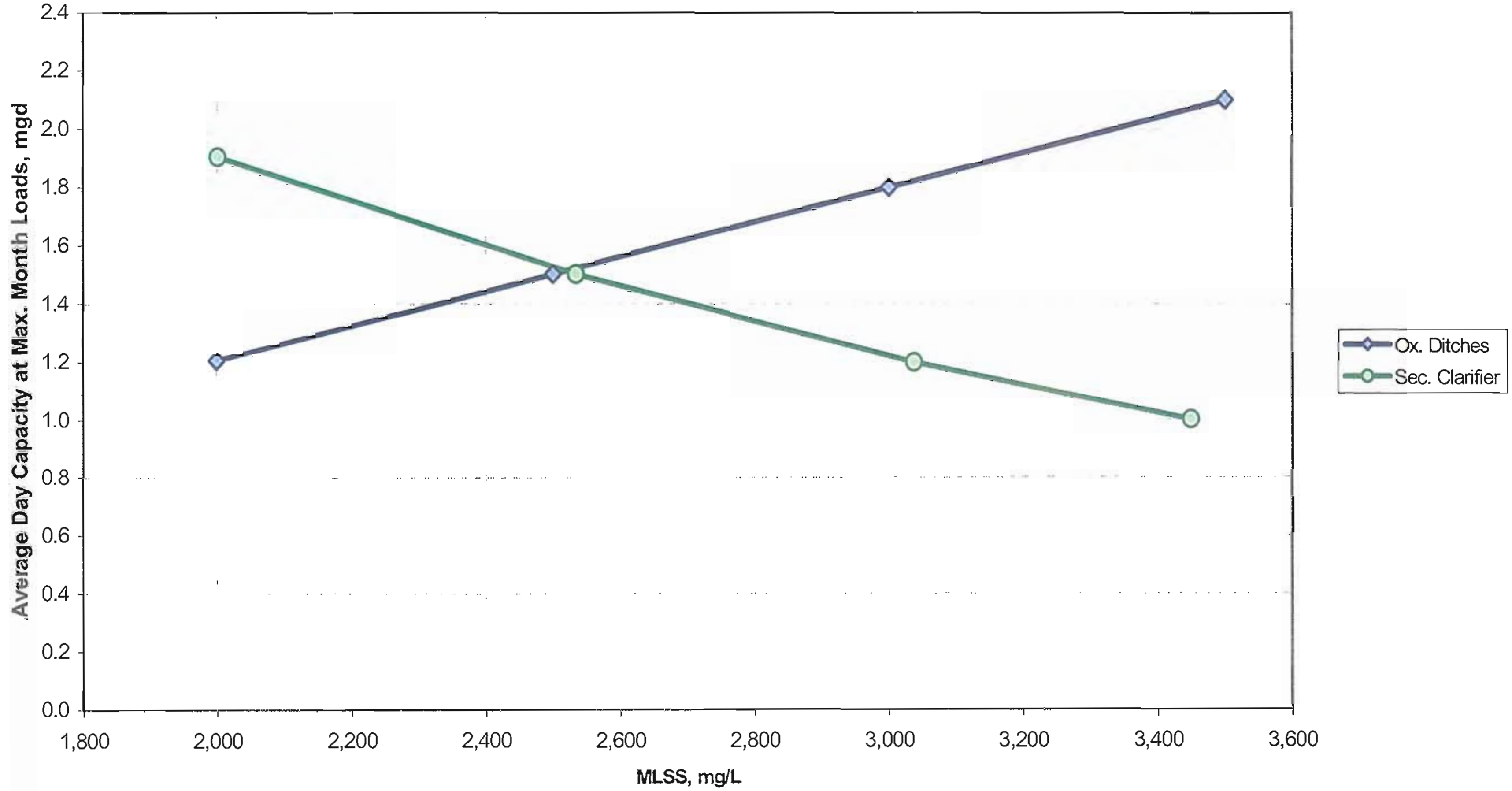
The activated sludge process includes the anoxic / aerobic basins, the surface aeration system, the secondary sedimentation basins, the mixed liquor return (MLR) pumps, and the return activated sludge (RAS) pumps.

The capacity of the oxidation ditches and anoxic basins is directly related to the operating MLSS concentration in the basins. The flow capacity of the basins increases with the operating MLSS. The estimated capacity of the existing basins based on process model results is illustrated in Figure 3A.5. With MLSS concentrations of 2,500 mg/L, 3,000 mg/L and 3,500 mg/L, the estimated capacity of the activated sludge basins is 1.5 mgd, 1.8 mgd and 2.1 mgd, respectively. However, the operating MLSS concentration also determines the capacity of the secondary clarifiers, as discussed below. The Biotran process model output is included in Appendix D.

The secondary sedimentation basin is another key process unit in the operation of the activated sludge system. The clarifier safety factor (CSF) was used as the limiting criterion to determine the capacity of the secondary sedimentation basins. The clarifier settling safety factor is the ratio between the maximum settling velocity of the mixed liquor and the basin overflow rate. The maximum settling velocity of the mixed liquor is determined by the settleability characteristics of the sludge, and was predicted based on a sludge volume index (SVI) value of 175 mL/g. For comparison, the average SVI for the Airport WRF between 2006 and 2009 was 167 mL/g.

The significance of the SVI value used for design is the impact on the predicted initial settling velocity (ISV) of the sludge, as the clarifier safety factor is defined as the ratio between the surface overflow rate and the ISV. There are several published relationships between SVI and ISV. For this project, the Daigger correlation and an SVI value of 175 mL/g were used for the analysis. The resulting ISV values using the Daigger correlation for SVI values of 175 and 200 mL/g (MLSS of 2,500 mg/L), are 7.0 and 6.4 ft/hr, respectively. The clarifier safety factors using the Daigger correlation and SVI values of 175 and 200 mL/g are 2.3 and 2.1, respectively, for an MLSS concentration of 2,500 mg/L and an average daily flow of 1.5 mgd.

The Pitman SVI-ISV correlation with an SVI of 150 mL/g is another correlation typically used to design and evaluate secondary clarification, and is representative of poor sludge settling characteristics. For comparison, the predicted ISV using the Pitman correlation and is 6.6 ft/hr for an SVI of 150 mL/g and an MLSS concentration of 2,500 mg/L. The clarifier safety factor using this approach is 2.2 for an average daily flow of 1.5 mgd.



SECONDARY SYSTEM CAPACITY ANALYSIS

FIGURE 3A.5

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Evaluation of the secondary clarification capacity was based on using the Daigger correlation and an SVI value of 175 mL/g. The estimated secondary clarifier capacity is considered to be conservative for clarification purposes, representative of poor sludge settling characteristics. It is expected that corrective action will be taken for conditions that lead to ISV values below 6.4 ft/hr.

The target CSF was determined based on the peak day flow peaking factor and an additional safety factor of 15 percent to account for variability in sludge settling characteristics, resulting in a CSF target value of 2.3. It is Carollo's standard practice to design for a minimum operating CSF of 2.0 under average day flows with one secondary clarification basin out of service. However, the Airport WRF has only one operating secondary clarifier, with no redundant units. A minimum CSF of 2.3 with the existing unit in service was used for the capacity evaluation herein.

The process model includes a calculation of the allowable MLSS for a given plant flow, based on the relationship between MLSS and the maximum settling velocity of the mixed liquor to maintain the target CSF. As illustrated in Figure 3A.5, the secondary clarifier capacity is inversely related to the MLSS concentration.

The treatment capacity of the activated sludge system depends heavily on the design MLSS used to evaluate the system. At higher MLSS concentrations, the capacity of the oxidation ditch basins is maximized, but the secondary clarifier capacity decreases. On the other hand, lower MLSS concentrations increase the flow capacity of the secondary clarifiers, but the capacity of the activated sludge basins is reduced.

Figure 3A.5 summarizes the process model results for the secondary treatment evaluation. The capacity of the existing activated sludge basins and secondary clarifier is estimated at 1.5 mgd, with an operating MLSS concentration of 2,500 mg/L. The optimum MLSS concentration for the existing secondary system is 2,500 mg/L, in order to maximize the capacity of both the activated sludge basins and the secondary clarifier at approximately 1.5 mgd. As explained above, additional clarifier capacity would be required to operate the activated sludge basins with an MLSS concentration higher than 2,500 mg/L.

<u>Aeration System Capacity</u>

The treatment capacity of the installed brush aerators is estimated at 1.5 mgd. The existing aeration equipment was evaluated under winter and summer conditions with the process model, and the required horsepower (HP) per aerator unit was maintained below 40 HP. A clean water standard oxygen transfer rate (SOTR) of 2.75 lb/hp-hr was used for the analysis based on information in the design documents. Supplemental aeration will be required for flows beyond 1.5 mgd.

RAS and MLR Pumping

RAS pumps have a rated capacity of 444 gpm each, with one pump in operation and one pump in standby. Based on process model calculations, the installed RAS pumping capacity is able to maintain the required RAS flows up to a plant flow of 1.5 mgd.

The RAS pumps firm capacity (0.64 mgd with one pump in service) translates to an underflow (RAS and WAS) ratio of 43 percent at the estimated average day flow capacity of the activated sludge system and secondary clarifier of 1.5 mgd. The underflow average day flow calculated with the process model for an influent flow of 1.5 mgd is 0.71 mgd, or an underflow ratio of 47 percent. The existing RAS pumps are slightly undersized in order to maintain the required underflow ratio under average day conditions with one pump in service. It is estimated that the standby pump will be required to operate in order to maintain the required underflow (0.71 mgd) at a plant flow of 1.5 mgd.

The recommended installed RAS pumping capacity (all units in service) is based on a minimum pumping capacity required at peak flows, estimated to be 1.26 mgd for a plant flow of 1.5 mgd, based on the process model calculations. The currently installed capacity of 1.28 mgd is adequate based on this criterion.

The existing MLR pumps (3,800 gpm each) provide sufficient capacity to treat flows up to the maximum capacity of the activated sludge basins. These pumps can maintain a minimum MLR flow ratio of 4 for each of the activated sludge trains, up to plant flows of 2.5 mgd.

4.3.3.3 Tertiary Treatment

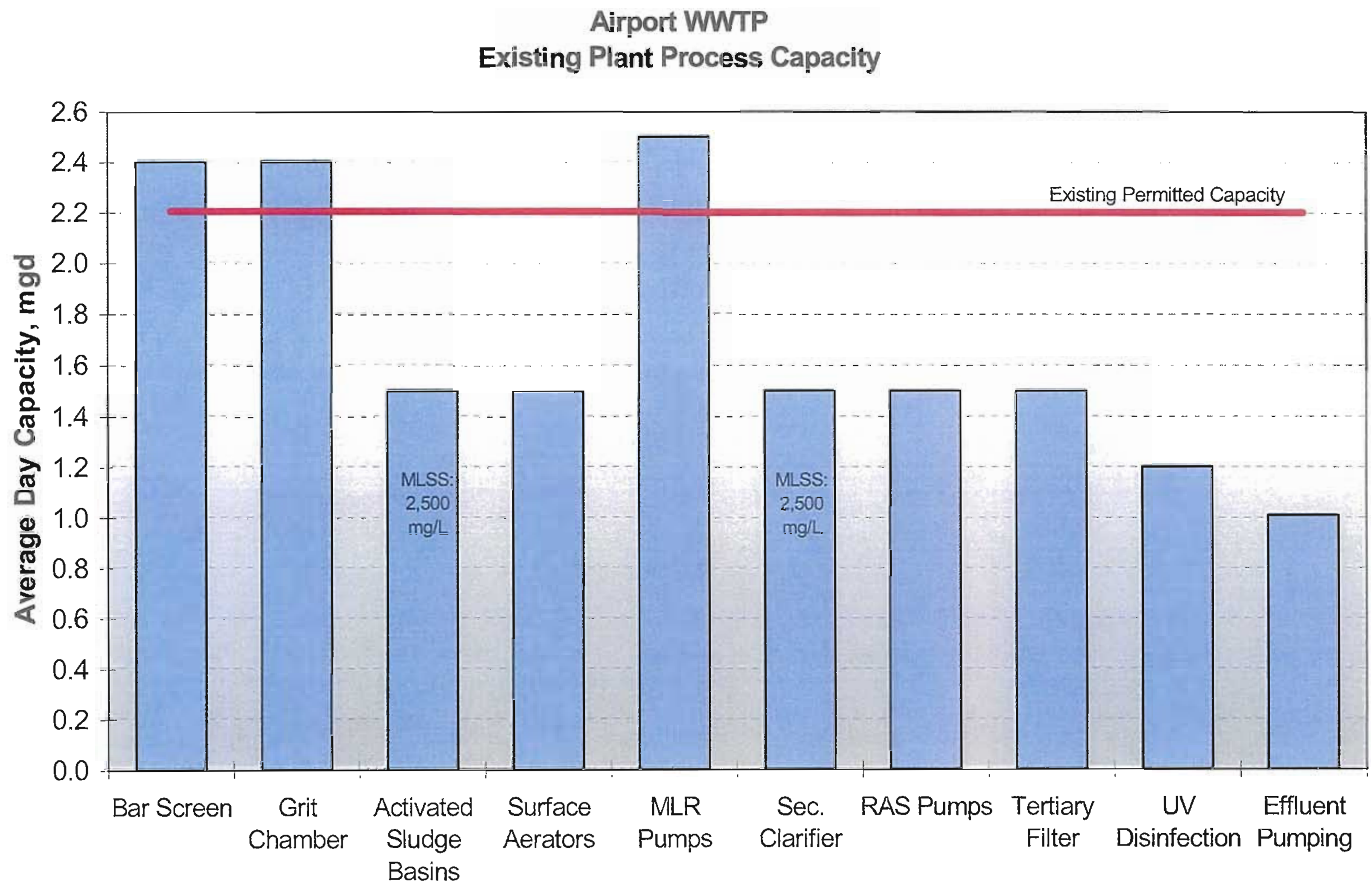
The existing single tertiary filter was evaluated in terms of the hydraulic loading at average and peak day flow conditions. The existing filter was designed for an average day flow of 1.5 mgd, and a peak flow of 3.0 mgd, based on hydraulic loading rates of 2 and 4 gpm/sf for average day and peak day flows, respectively. It should be noted that the second filter originally considered in the 1998 expansion design project was not constructed due to insufficient funding. The performance and evaluation of the tertiary filtration facilities is reviewed in more detail in Technical Memorandum No. 7 of this project.

The ultraviolet disinfection equipment was originally designed for an average daily flow of 1.2 mgd and a peak hourly flow of 3.6 mgd. Based on the equipment-rated flows, additional disinfection equipment has sufficient capacity to operate at the current average day and peak hourly flows.

4.3.3.4 Effluent Pumping

The existing effluent pump station have a total rated capacity of approximately 3.0 mgd with all three units in service. With a peak hour factor of 3, the ADF total capacity of the effluent pump station is approximately 1.0 mgd.

Figure 3A.6 summarizes the capacity analysis estimate for the existing facilities at the Airport WRF. The current tertiary treatment facilities (filter and UV disinfection) limit the plant capacity at an average day flow capacity of 1.2 mgd. The current secondary treatment system has a capacity of 1.5 mgd mainly due to limitations in secondary clarification capacity. It should be noted that the second clarifier originally considered in the 1998 expansion design project was not constructed due to insufficient funding.



SUMMARY OF CAPACITY ANALYSIS ESTIMATE

FIGURE 3A.6

5.0 OPERATIONAL CONSIDERATIONS

5.1 Current Operations

5.1.1 Headworks

The new headworks was designed to handle the ultimate plant capacity of 2.4 mgd (average day). The headworks consists of automatic and manual screens, Parshall flume flow metering, and gravity grit removal.

5.1.1.1 Bar Screens

The bar screen equipment is currently operating without any major concerns. Two bar screens are currently installed, one mechanically cleaned, climber type, and one manual type. Provisions have been made for future installation of a second mechanically cleaned bar screen. Both screens have 3/4-inch clear space between bars with a channel depth of 3 feet 11 inches and a channel width of 2 feet 6 inches. The automatic screen has dual controls that operate the screen on a timed basis or channel level. The manual screen is only used when the mechanically cleaned screen is out of service.

5.1.1.2 Flow Metering

Influent flow is measured using a Parshall flume with an ultrasonic level sensor. Flow is recorded using a 24-hour circular chart with a totalizer. The flume is located between the bar screens and the grit basin.

5.1.1.3 Grit Removal

A gravity type grit removal basin with a grit dewatering screw is located downstream of the Parshall flume. Velocity through the grit chamber is such that the heavier inorganic particles, such as rocks and cinders, sand and other such debris will settle out. The lighter organic particles will not settle out and pass on to the next treatment process. Some heavier organic material such as corn may also settle out with the inorganic material. Grit is conveyed by the rotating bottom scraper to a sump where it is picked up by a dewatering screw. The dewatering screw deposits the collected grit in a container for disposal.

The grit removal equipment is in good working condition, other than a few minor mechanical repairs that have been required. The grit removal process seems to be working well, and relatively small amounts of grit have been observed in the anoxic basins, when they have been taken out of service.

5.1.2 Biological Treatment

Additions to the original biological process included two anoxic basins and one oxidation ditch. The original oxidation ditch basin was retained for use when the loadings to the treatment facility require it. Additionally, the unused oxidation ditch was planned to be used as a pretreatment basin for industrial wastewater that could upset the biological process. The anoxic basins are used to denitrify the wastewater and the oxidation ditches are used to nitrify ammonia and remove carbonaceous BOD.

The plant had been operating with only the newer oxidation ditch basin (Oxidation Ditch No. 1) in service. The original oxidation ditch basin (Oxidation Ditch No. 2) was being used as an emergency equalization basin. Due to increased loadings in the plant influent, plant staff started operating Oxidation Ditch No. 2 at the end of 2008, in order to increase the aerobic solids retention time and improve the system operation, especially under winter conditions. Initially, the oxidation ditch basins were operated in series, which presented some challenges for the operation of the activated sludge system. After verifying that both oxidation ditch basins were connected to the secondary clarifier, plant staff switched to a parallel operation of the anoxic and oxidation ditch basins, as was originally intended in the plant design.

After a period of stabilization, plant staff has been able to produce a very good quality effluent (TN < 5 mg/L) with the operation of the activated sludge system in the parallel mode. The main optimization parameters have been the aerator and mixed liquor return equipment operation. Timers are currently being used to control dissolved oxygen concentrations in the oxidation ditches (via adjustment of aerator times), and to control mixed liquor return flows back to the anoxic basins.

5.1.2.1 Anoxic Basins

The anoxic basins are used to denitrify the waste stream by converting nitrates to nitrogen gas. The nitrogen gas leaves the solution and goes into the atmosphere. Each anoxic basin is divided into two cells of equal size. Each cell contains a down draft mixer to keep the solids in suspension.

5.1.2.2 Oxidation Ditch

The new oxidation ditch (Oxidation Ditch No. 1) with a volume of 117,000 cubic feet was added to the treatment facility in 1998. The original oxidation ditch (Oxidation Ditch No. 2), with a volume of 93,240 cubic feet, is smaller and shallower than the new ditch. Flow from the anoxic basins enters the oxidation ditches through submerged inlets. The basin inlets are located on the north end of each basin. The original Oxidation Ditch No. 2 basin inlet is on the west side of the basin, near the north brush aerator. Both ditches are mixed and aerated with brush aerators.

Each oxidation ditch has a mixed liquor recycle pump wet well connected to it that contains one submersible pump. These submersible pumps are used to recycle mixed liquor to the anoxic basins. Flow from the oxidation ditches is discharged to the secondary clarifier.

5.1.3 Secondary Clarification

There is currently one secondary sedimentation basin in operation. This basin has a diameter of 60 feet and a side water depth of 15 feet, and was added in the 1998 plant expansion. Provisions have been made for adding an additional secondary clarifier in the future. The original 50-foot diameter clarifier, with an 8-foot side water depth had been left as a standby unit. However, the 50-foot diameter clarifier basin was recently converted into a solids holding and thickening basin and is no longer available for secondary clarification.

Solids removed from the clarifier are either returned to the anoxic basin or wasted. Waste solids are bled off the return solids line. Both solid streams are metered. Scum collected from the surface of the clarifier is wasted from the system. The scum volume is not metered. The clarification process is operating properly, but the basin capacity currently limits the secondary treatment capacity of the plant.

RAS pumping had been problematic in the past. The previous RAS submersible centrifugal pump would constantly plug and required frequent maintenance. The pumps were replaced with new units that have non-clog impellers (Flygt, type “N” impeller), which have practically eliminated clogging issues and simplified RAS operation. A second pump was recently added for added capacity and redundancy.

One of the two RAS pumps is currently connected to a variable frequency drive (VFD). The pump VFD allows a variable flow control depending on the process requirements. However, the RAS flow is not currently flow paced because the RAS VFD is not connected to the influent flow meter signal in any manner.

Sludge wasting is achieved using the RAS pumps, by opening a valve off the main RAS line. Waste sludge is continuously fed into the solids holding basin, where it is equalized and thickened before it is pumped to the dewatering centrifuge.

5.1.4 Traveling Bridge Filters

One traveling bridge filter, using sand as the filter medium, with capacity of 1.2 mgd at average flows and a peak flow of 2.4 mgd, has been installed. Firm capacity was not required, as effluent for indirect aquifer recharge (surface basins) does not have to be filtered. The filter is a multi-cell unit that allows filtering and backwashing to occur simultaneously.

The existing filter can generally produce effluent with a turbidity below 2 NTU. However, there have been several days over the past three years when the average daily turbidity values have exceeded 2 NTU. Calcium hypochlorite (5 lb/day) is currently being added on a regular basis to keep filters from plugging.

5.1.5 Ultraviolet Disinfection

New ultraviolet disinfection equipment was retrofitted into the original chlorine contact channel. The current disinfection equipment was sized for a peak flow of 3.6 mgd. Provisions to allow for expansion to a peak flow of 7.2 mgd have been made.

The disinfection system operates with a constant UV dose, without any flow pacing. The existing system is relatively easy to maintain, although plant staff have experienced some programming challenges with some of the alarms of the system.

The existing chlorination equipment was to provide supplemental disinfection for reclaimed water disinfection and to maintain a residual in the delivery pipeline.

5.1.6 Solids Handling

The current solids handling practice is dewatering undigested sludge, followed by landfill disposal. WAS is pumped to an aerated solids holding basin using pressure from the RAS pump. The solids holding tank is aerated with a 20-horsepower positive displacement blower and a coarse bubble diffuser system that maintain aerobic mixing conditions in the basin. Submersible WAS pumps in the solids holding basins pressurize the WAS line connected to the centrifuge feed pumps.

The existing centrifuge produces a dewatered cake with approximately 22 percent solids content, which is subsequently sent to landfill disposal. The belt filter press previously operated is being retained as a backup to the centrifuge dewatering system.

5.2 Plant Issues, Needs, and Operational Preferences

5.2.1 General

The plant does not currently have any type of monitoring or control system available. At the minimum, monitoring of key processes and alarms notifications are desirable in the short-term. Monitoring and alarms would improve the reliability of the system, providing operators the ability to identify major upsets during unattended operation periods. In the long-term, instrumentation and control elements could be incorporated in a plant control system for automation of the major processes, such as secondary process equipment. Automation of major processes will optimize energy consumption, and provide a more reliable operation of the treatment process.

5.2.2 Headworks

The openings of the existing screens let relatively large solids pass through. Under the next plant expansion, staff would like to evaluate the different screening and grit removal alternatives currently available. Screening requirements are also influenced by requirements of the treatment process. A screenings washer-compactor should be evaluated with the next headworks expansion.

It is standard practice to provide a bypass for mechanical screen units. A passive manually cleaned bypass screen is preferred by plant staff, and should be incorporated in any headworks expansion design.

The maximum flow that can be recorded with the existing influent flow meter chart recorder has been increased from 3.0 mgd to 5.0 mgd. There have been occasions when peak flows exceed 3.0 mgd. It is recommended that the recorded be updated to allow recording flows of the headworks peak design flows, which is currently 7.6 mgd.

5.2.3 Anoxic and Oxidation Ditch Basins

There is currently no automated control of rotor operation or MLR pumping. Aerator control can be automated based on dissolved oxygen concentrations in the basin, in order to optimize the biological treatment process and the energy consumption of the secondary process.

In order to de-couple oxygen supply from mixing requirements, plant staff is interested in evaluating the use of submersible mixers in the oxidation ditch basins.

5.2.4 Secondary Sedimentation Basin

There is currently only one secondary sedimentation basin in operation. While the equipment is operating properly, there is no redundancy in the secondary clarification process. More clarification capacity is required to increase plant capacity and provide redundancy. However, addition of secondary clarifier capacity needs to be evaluated within the context of the overall site master plan.

A positive means of continuous sludge wasting is required to improve process control and simplify operation of the RAS and WAS control system. Recent modifications to the sludge wasting system have been completed, and continuous wasting is currently being practiced. Level monitoring (and associated alarms) in the sludge holding basin are recommended to improve the reliability of the sludge wasting process.

RAS flows can be optimized by flow-pacing with the plant influent flow. One of the RAS pumps already has a VFD. It is recommended that RAS flow is flow paced to optimize process control.

5.2.5 Filtration and Disinfection

There is currently no redundancy in the filtration facilities. Specific recommendations regarding tertiary filtration are addressed in Technical Memorandum No. 7.

UV equipment is currently operated with a constant UV dose. In order to optimize energy usage, the UV dose could be paced based on flow and on the UV transmittance (UVT) of the reclaimed water.

5.2.6 Non-Potable Water System

The existing system does not provide sufficient pressure, nor does it provide appropriate pressure control. The existing system is not independent from the effluent pumping system, which provide challenges for an appropriate pressure control. The yard hydrants require more pressure to operate effectively. It is recommended that a new non-potable water system be evaluated.

5.2.7 Electrical

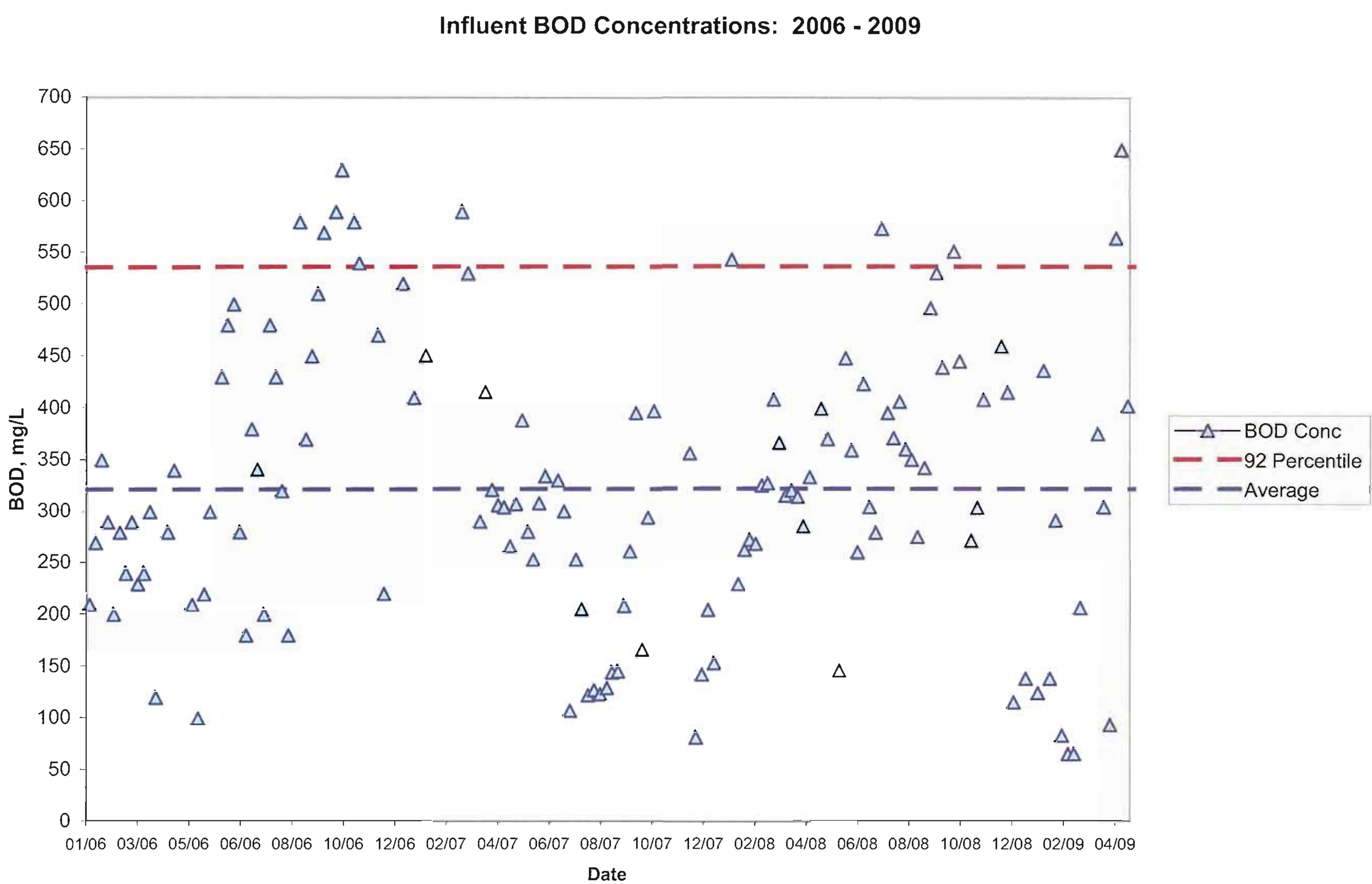
A detailed electrical evaluation is recommended. Currently, the following equipment can be maintained operational with the 150 kW stand-by power unit during a power outage.

- One effluent pump
- One brush aerator
- Two anoxic mixers
- Clarifier drive motor
- RAS pumps
- Lighting panel board
- One mixed liquor recycle pump

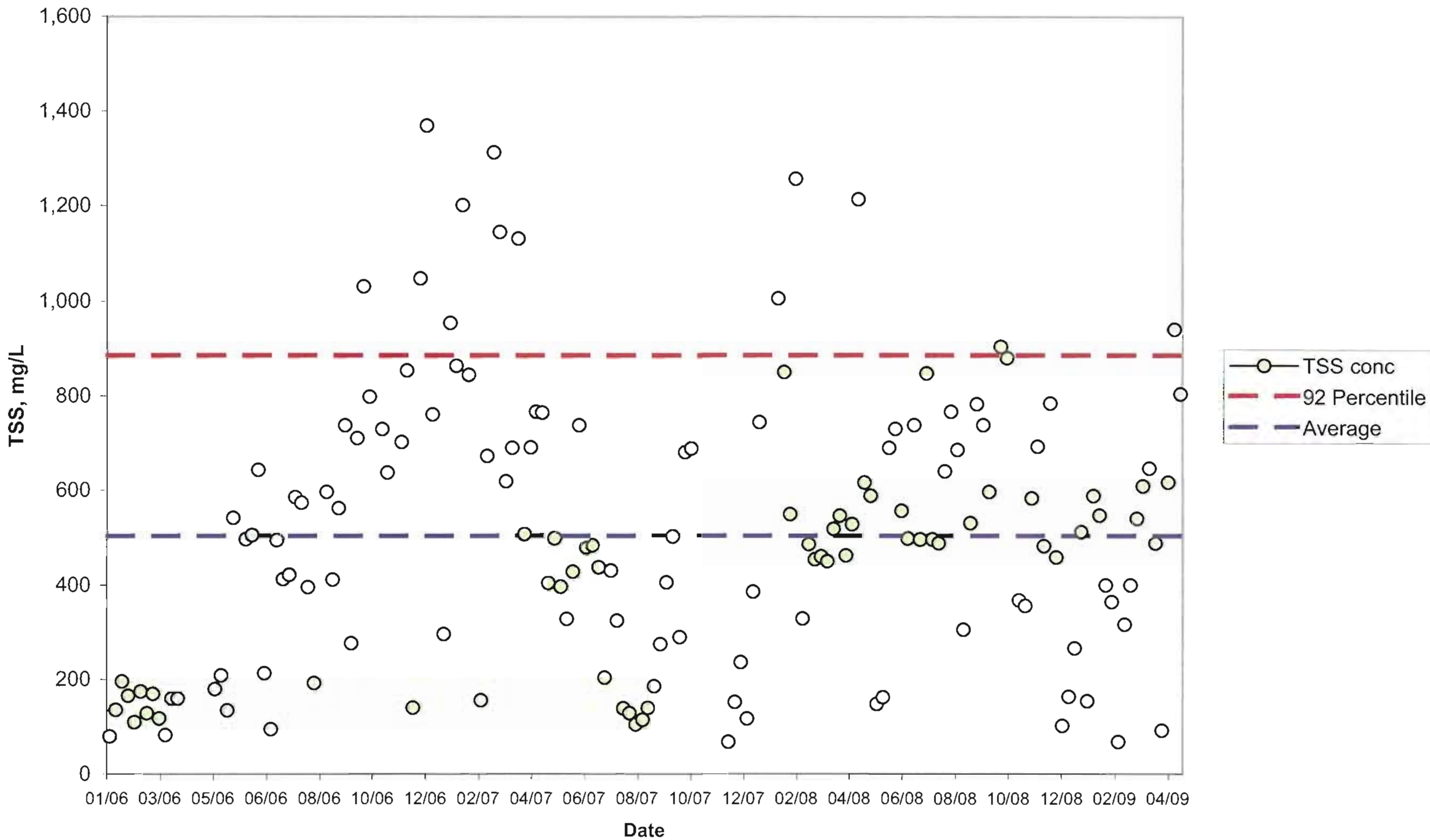
There are plans to replace the 300 kW standby power unit at the Sundog WWTP. Plant staff has expressed the intent of installing the 300 kW standby power unit at the Airport WRF. This addition to the electrical system would increase the plant reliability, as more equipment could be connected to standby power in the event of power failures. Power outages can be as long as 12 hours at the Airport WRF, and therefore it is important to increase the standby power generation capacity at the plant. A detailed electrical evaluation is recommended to determine how the 300 kW unit can be best incorporated into the Airport WRF electrical system.

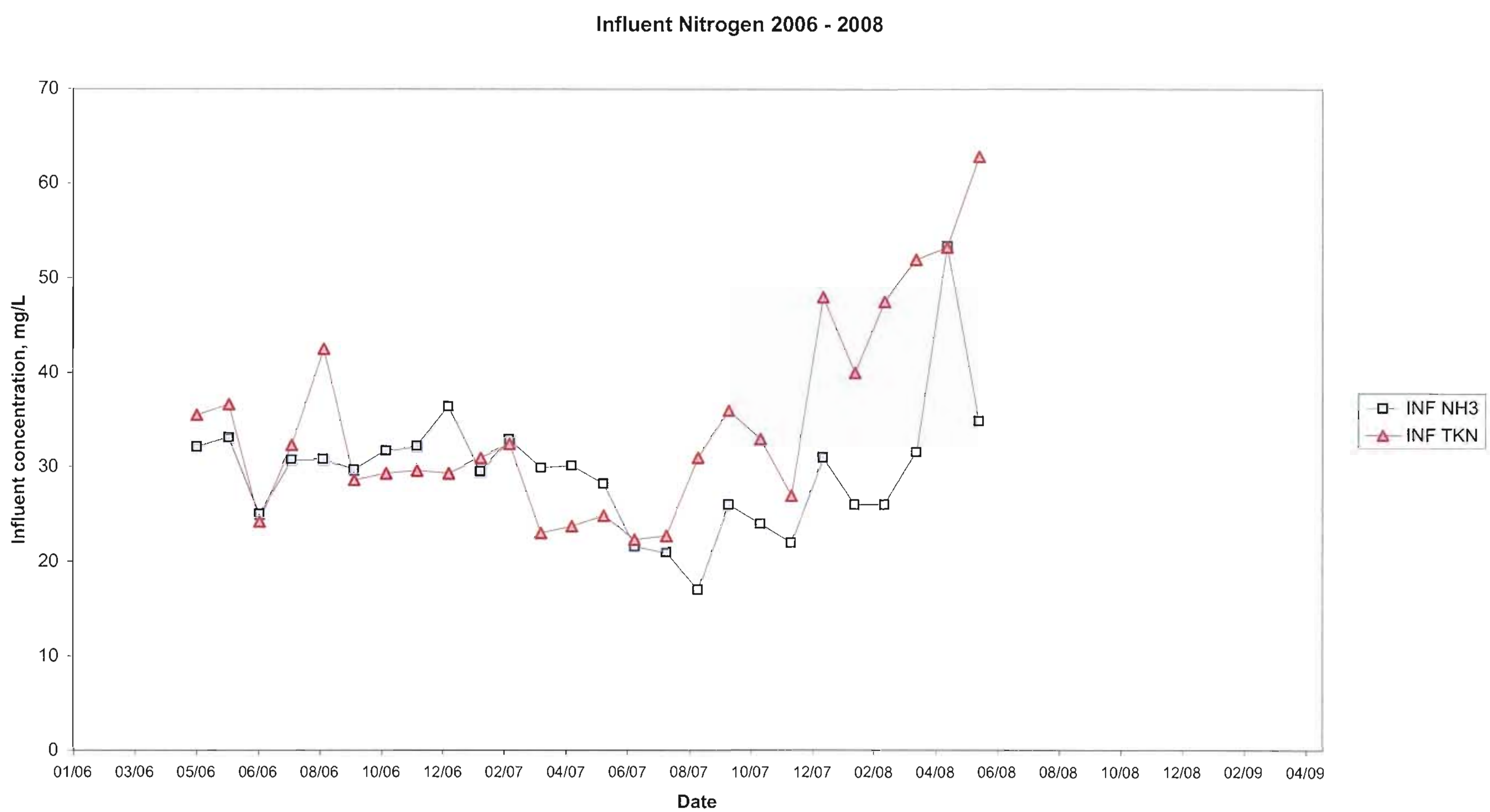
APPENDIX A

GRAPHS

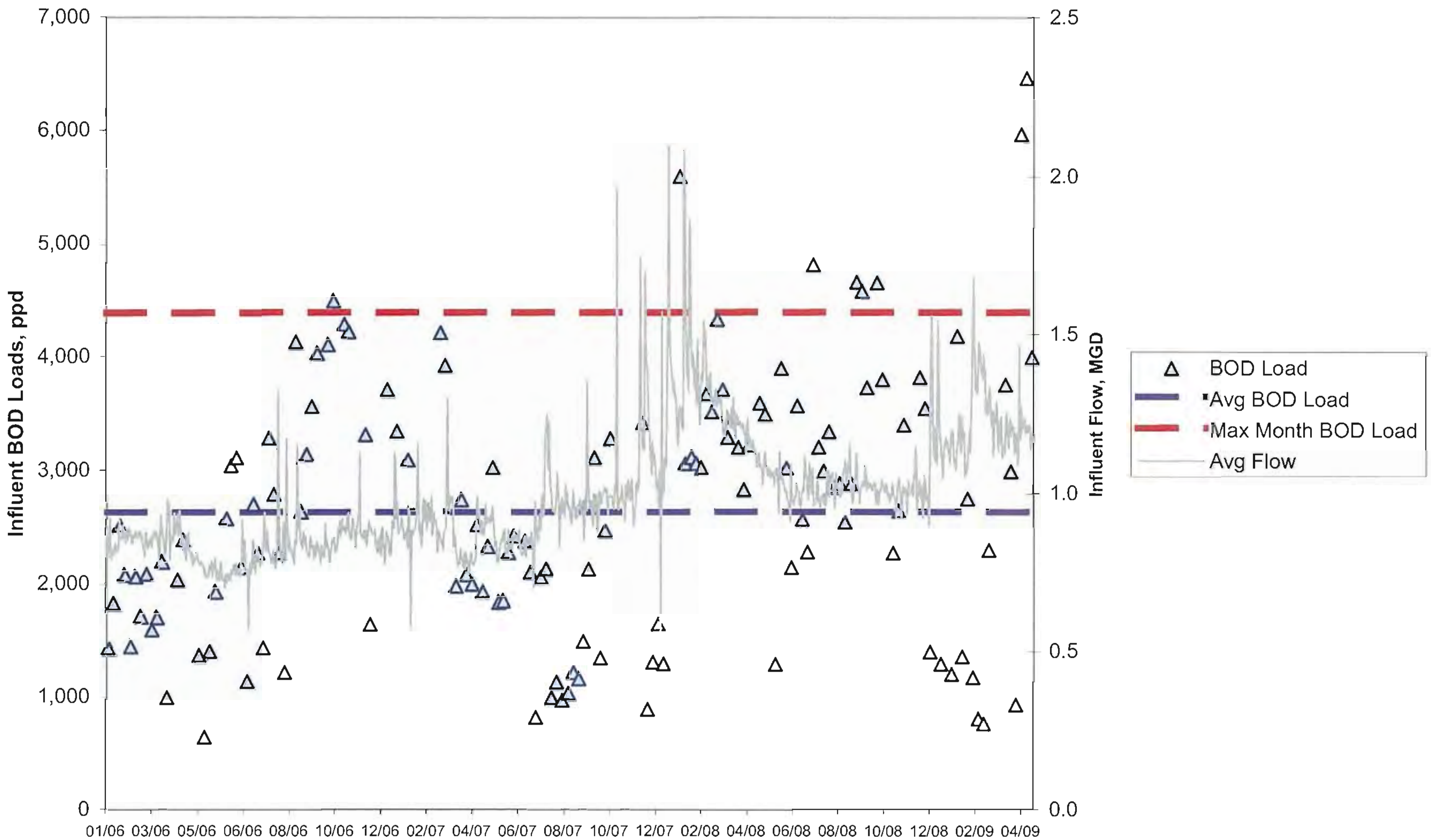

Influent BOD Concentrations: 2006 - 2009
BOD, mg/L
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
01/06 03/06 05/06 06/06 08/06 10/06 12/06 02/07 04/07 06/07 08/07 10/07 12/07 02/08 04/08 06/08 08/08 10/08 12/08 02/09 04/09
Date
BOD Conc
92 Percentile
Average

Influent TSS Concentrations: 2006 - 2009

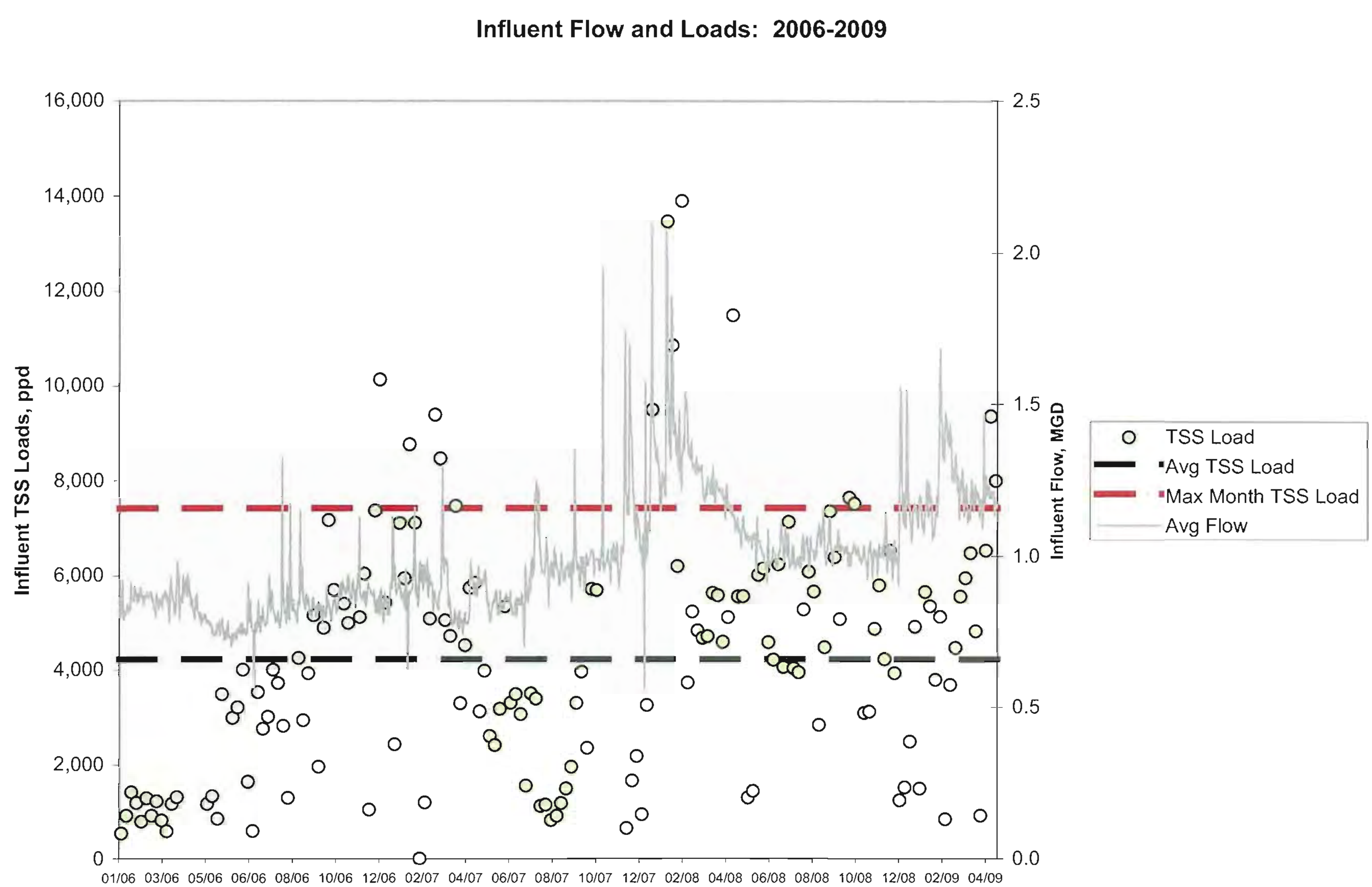



Influent Nitrogen 2006 - 2008
Influent concentration, mg/L
0
10
20
30
40
50
60
70
01/06
03/06
05/06
06/06
08/06
10/06
12/06
02/07
04/07
06/07
08/07
10/07
12/07
02/08
04/08
06/08
08/08
10/08
12/08
02/09
04/09
Date
INF NH3
INF TKN

Influent Flow and Loads: 2006-2009

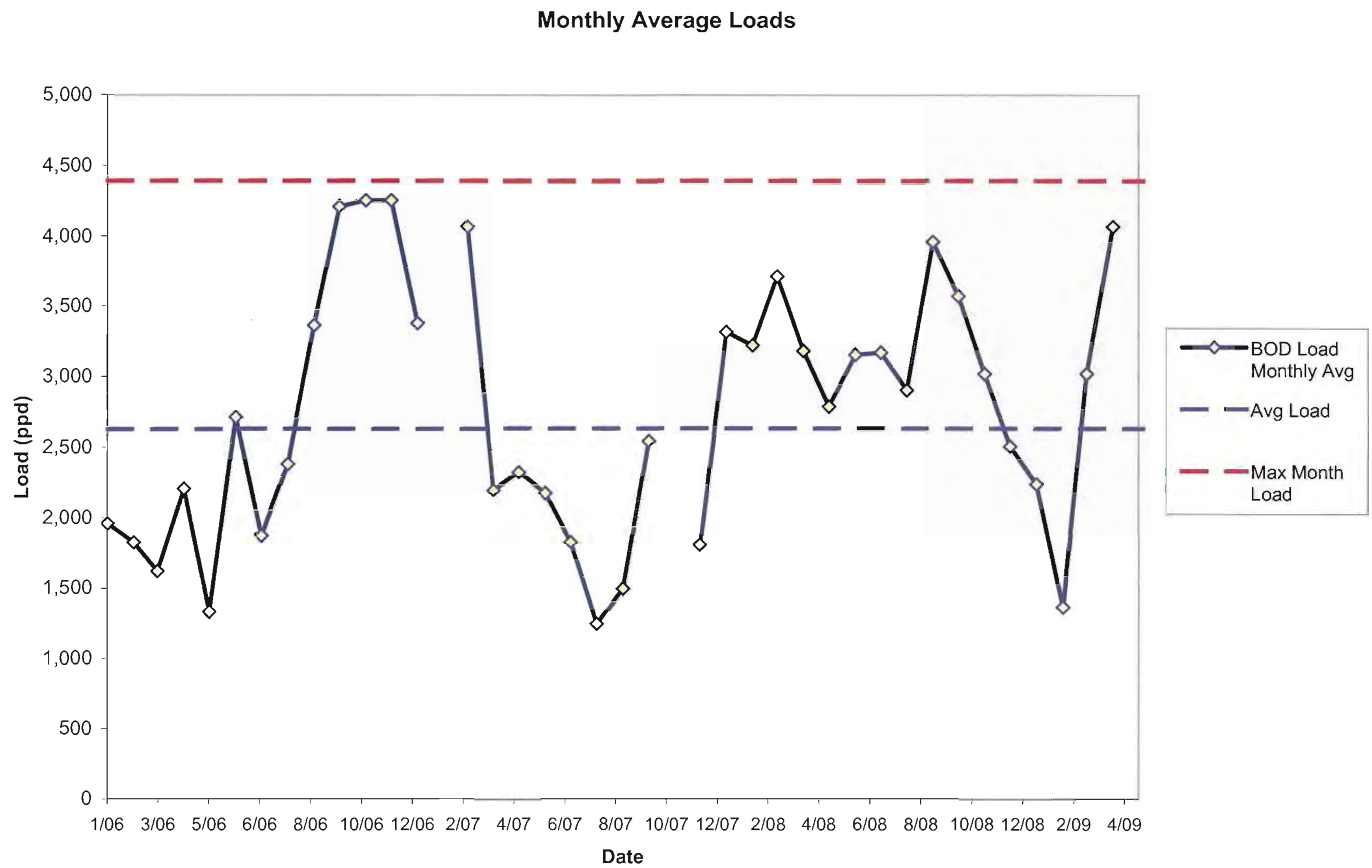


carollo

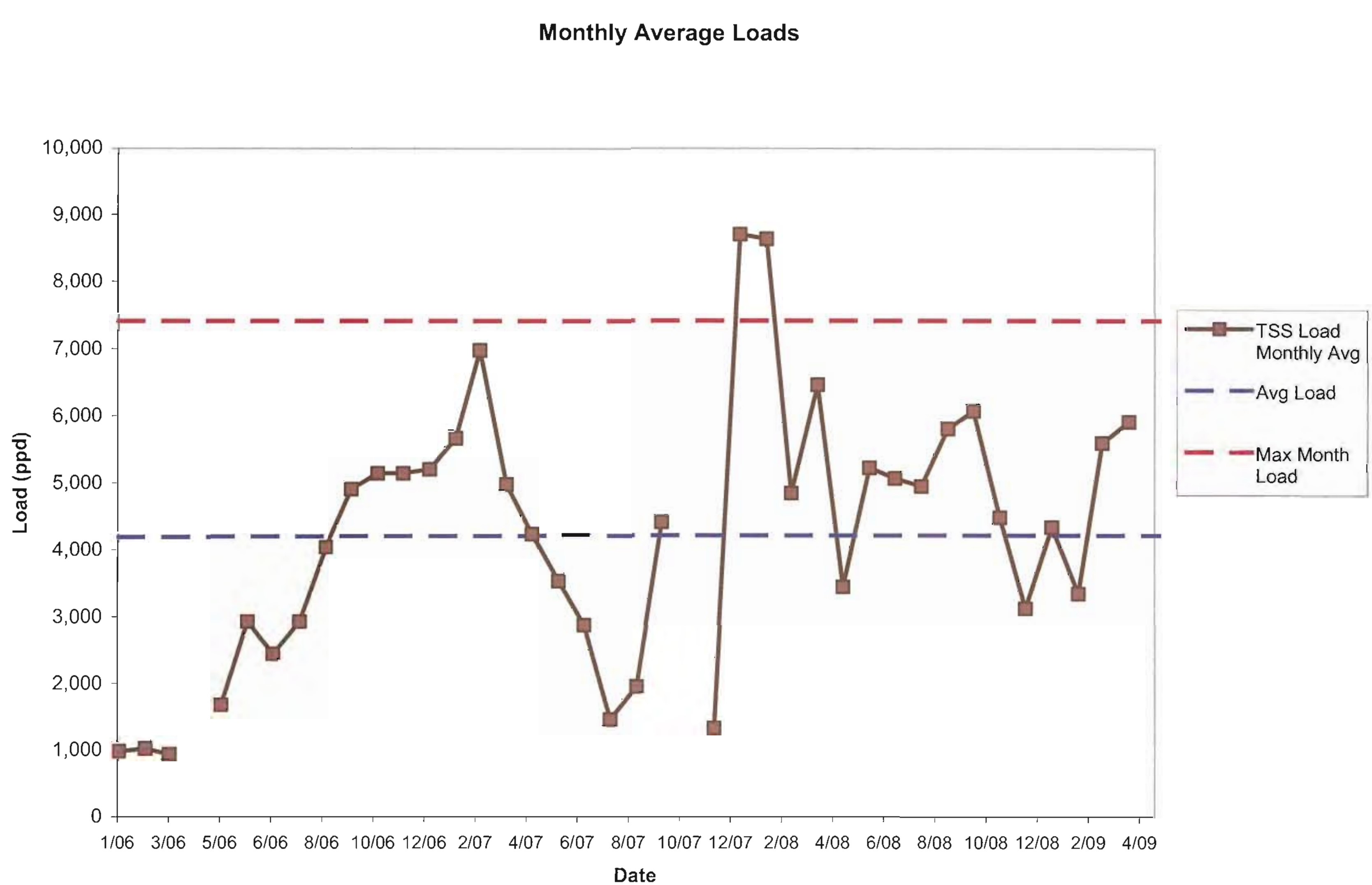


Influent Flow and Loads: 2006-2009
Influent TSS Loads, ppd
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Influent Flow, MGD
2.5
2.0
1.5
1.0
0.5
0.0
01/06 03/06 05/06 06/06 08/06 10/06 12/06 02/07 04/07 06/07 08/07 10/07 12/07 02/08 04/08 06/08 08/08 10/08 12/08 02/09 04/09
TSS Load
Avg TSS Load
Max Month TSS Load
Avg Flow

carollo

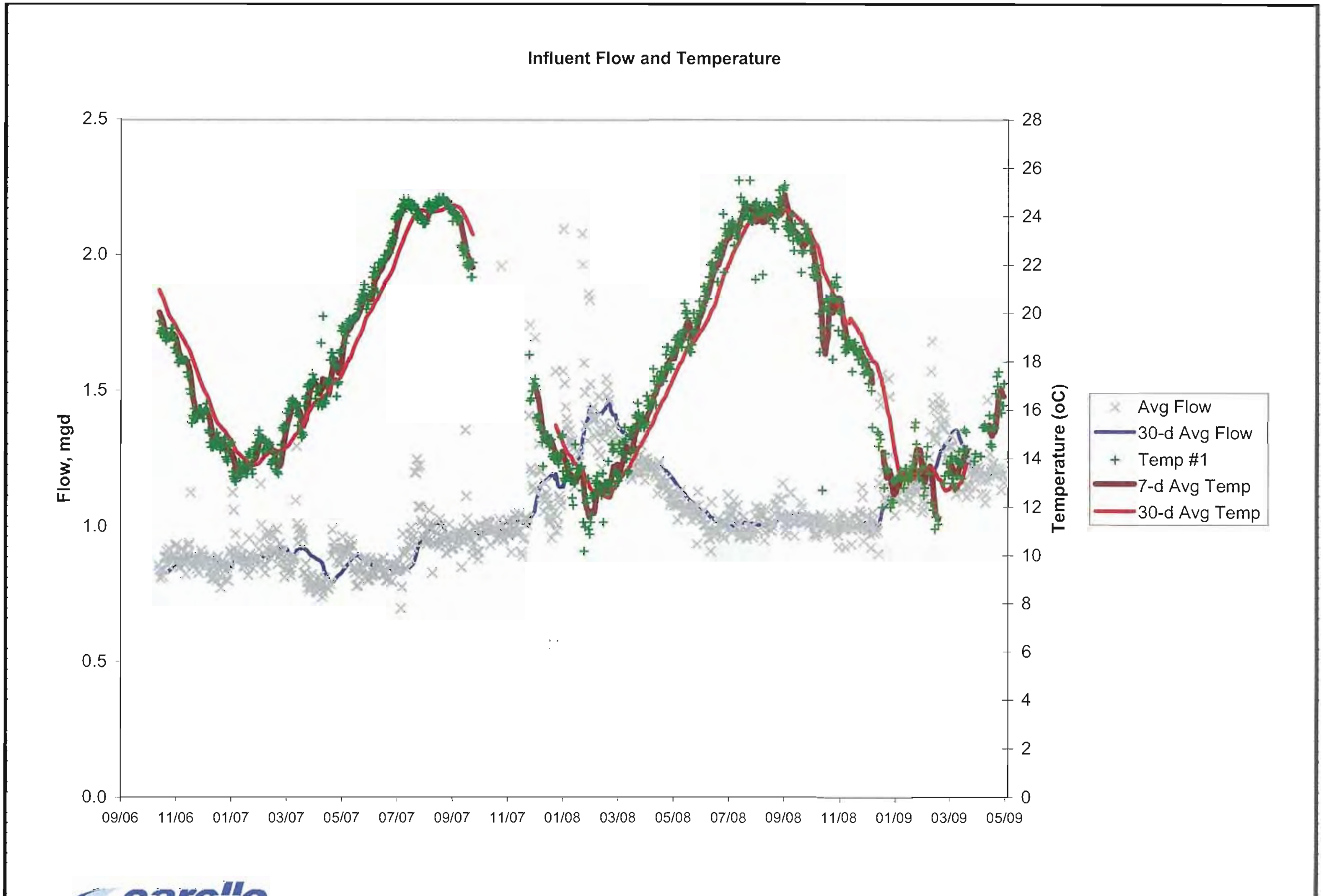


Monthly Average Loads
Load (ppd)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/06 3/06 5/06 6/06 8/06 10/06 12/06 2/07 4/07 6/07 8/07 10/07 12/07 2/08 4/08 6/08 8/08 10/08 12/08 2/09 4/09
Date
BOD Load Monthly Avg
Avg Load
Max Month Load

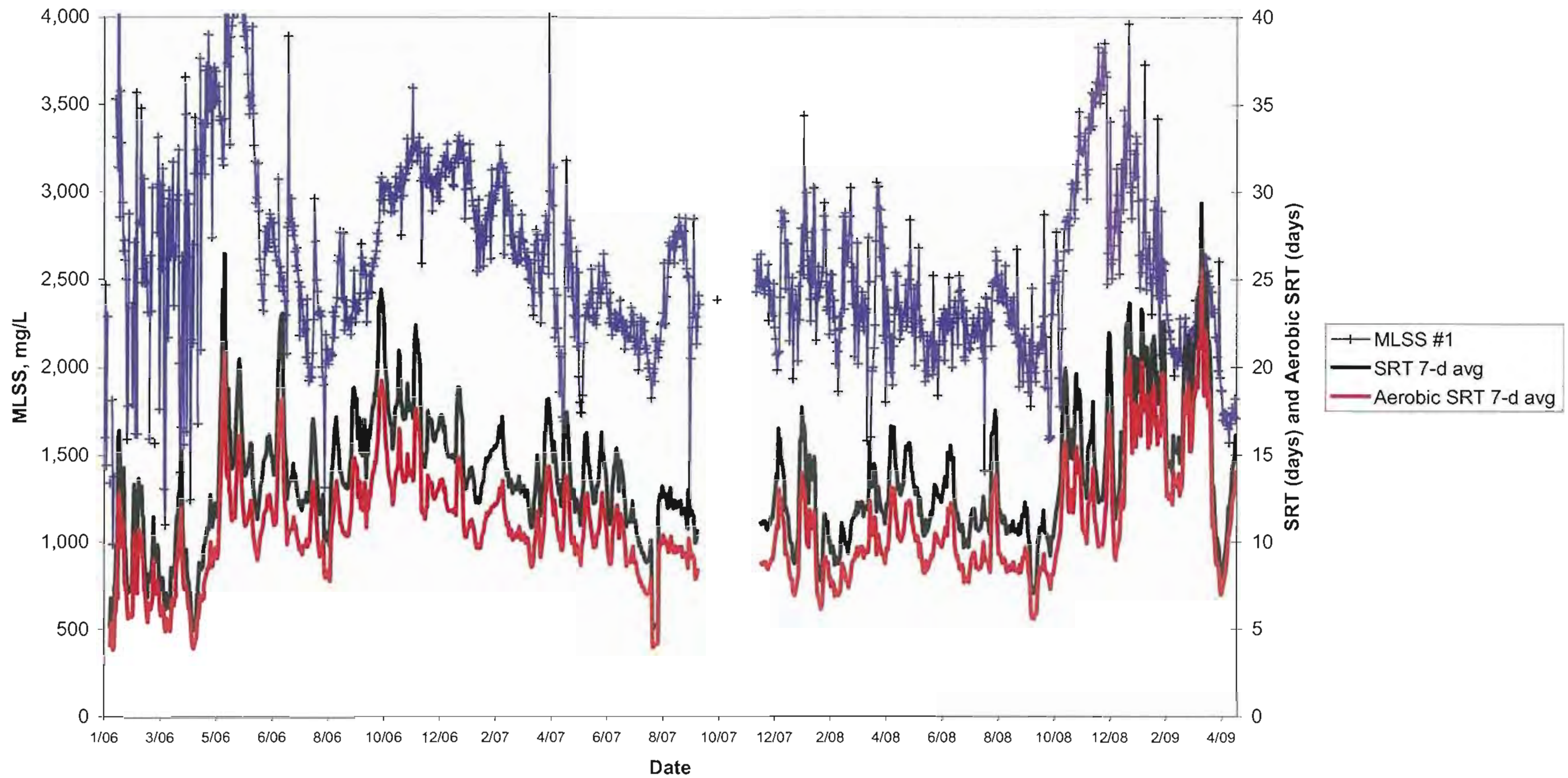


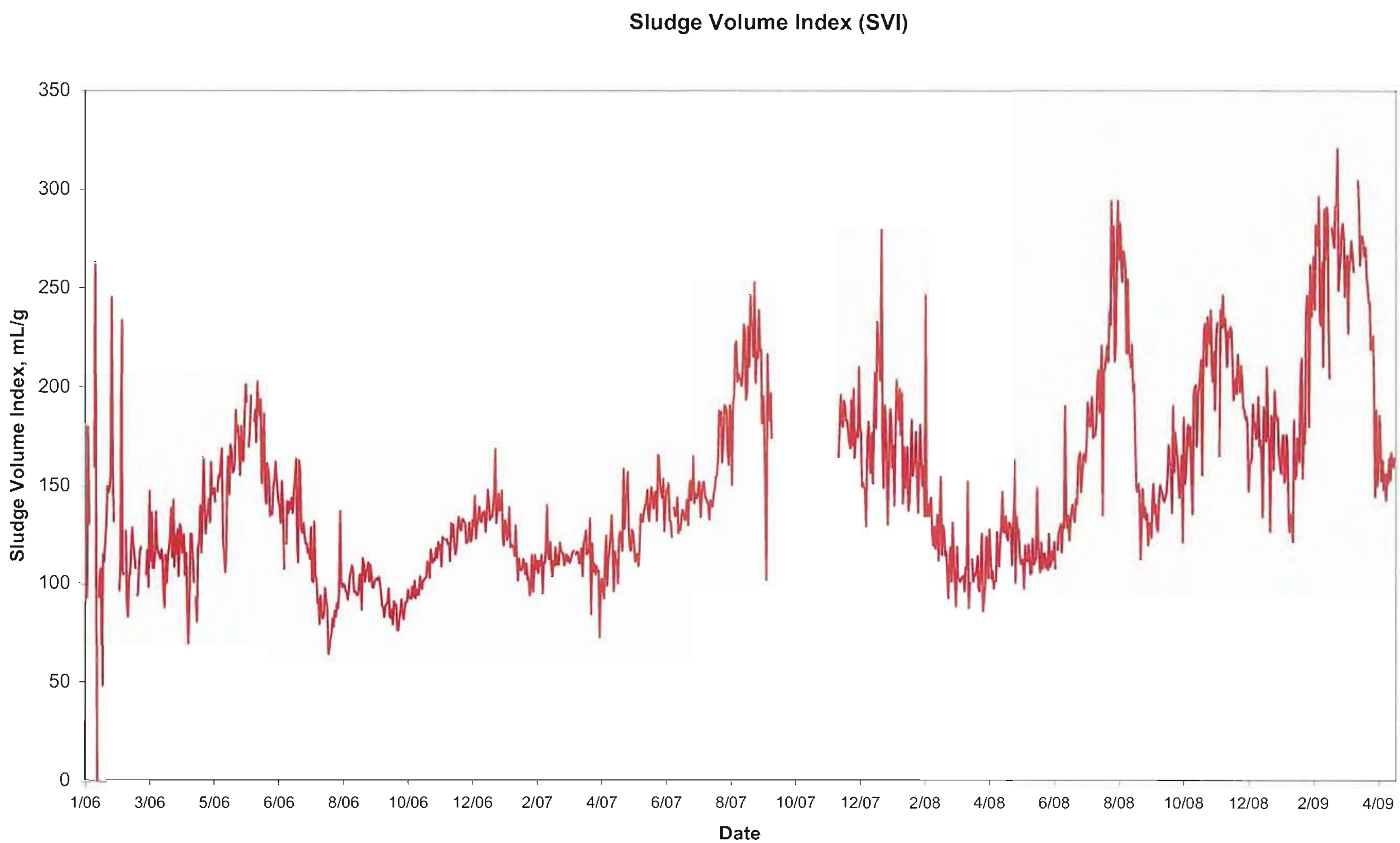
Monthly Average Loads
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Load (ppd)
1/06
3/06
5/06
6/06
8/06
10/06
12/06
2/07
4/07
6/07
8/07
10/07
12/07
2/08
4/08
6/08
8/08
10/08
12/08
2/09
4/09
Date
TSS Load Monthly Avg
Avg Load
Max Month Load

carollo

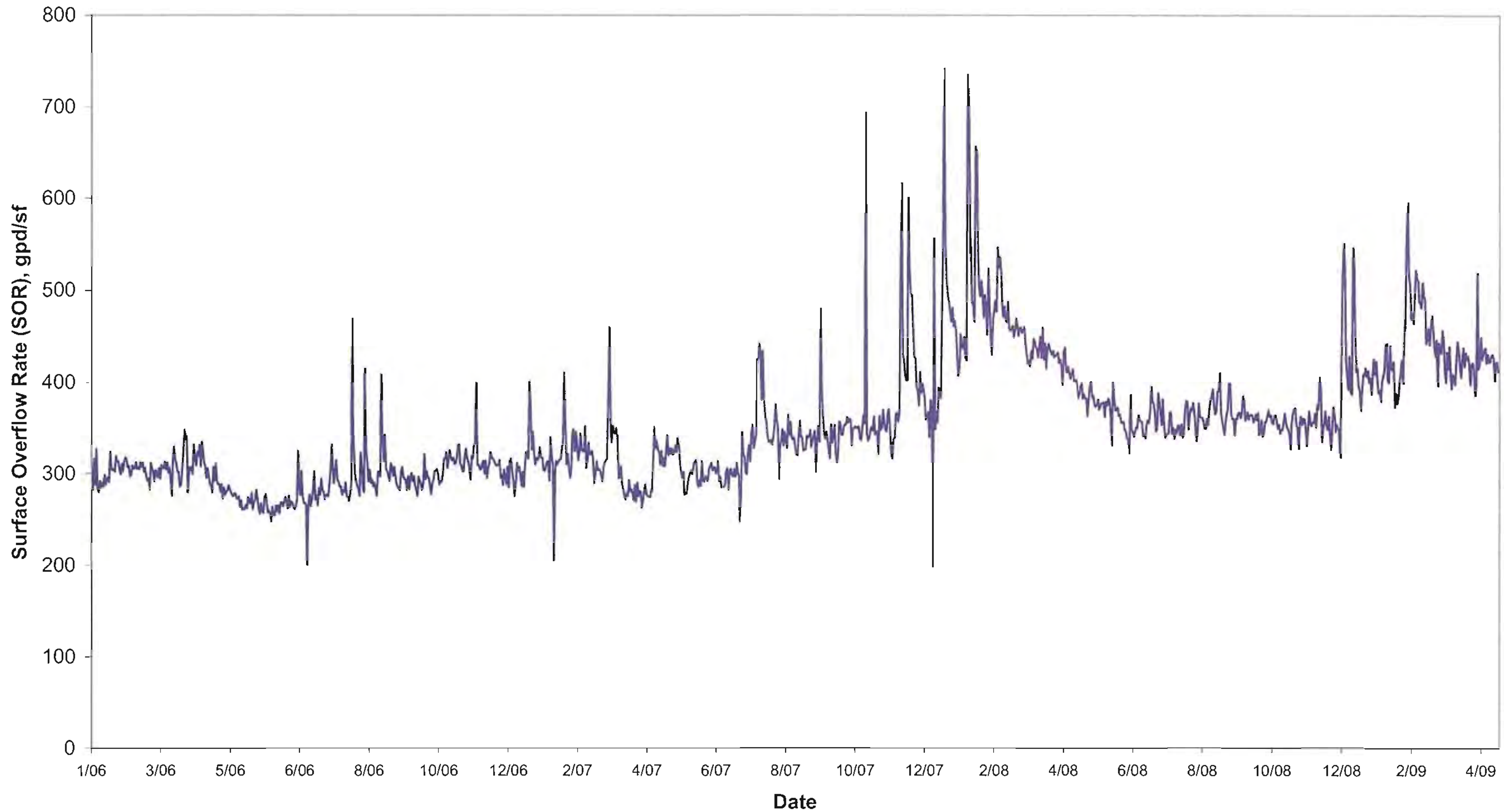

Influent Flow and Temperature
Flow, mgd
2.5
2.0
1.5
1.0
0.5
0.0
Temperature (oC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
09/06
11/06
01/07
03/07
05/07
07/07
09/07
11/07
01/08
03/08
05/08
07/08
09/08
11/08
01/09
03/09
05/09
Avg Flow
30-d Avg Flow
Temp #1
7-d Avg Temp
30-d Avg Temp

Aeration Basin Parameters

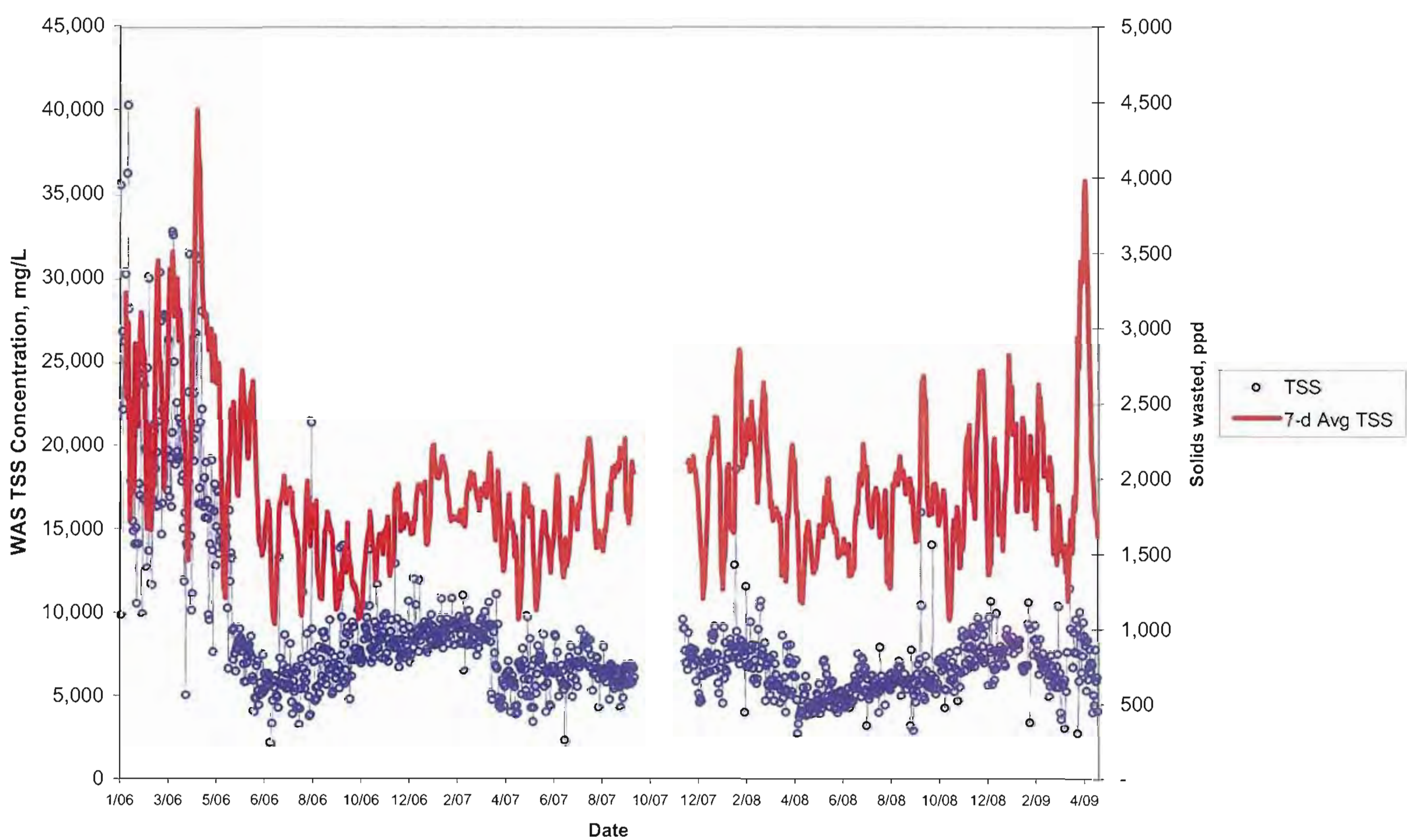


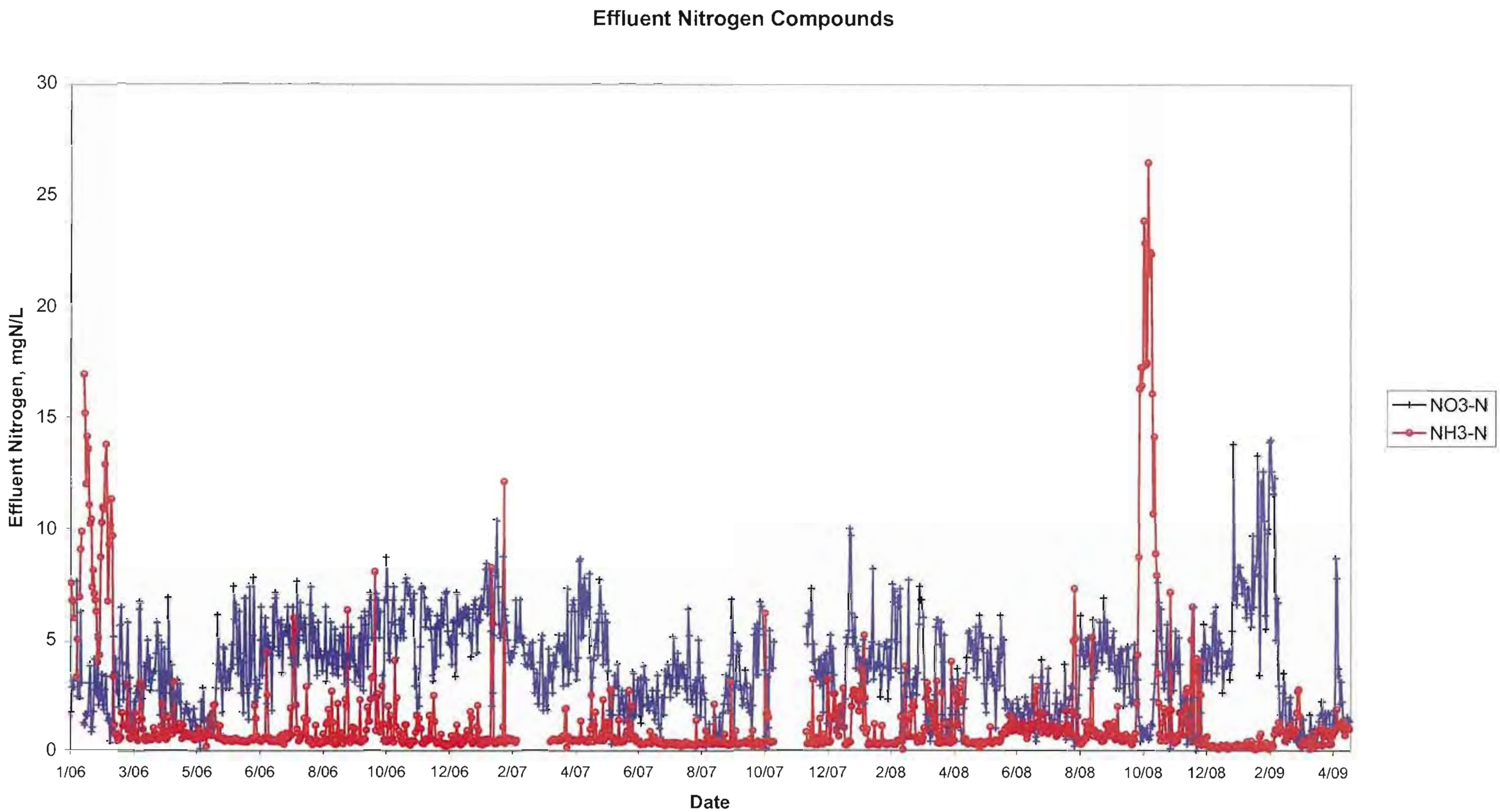

Sludge Volume Index (SVI)
Sludge Volume Index, mL/g
350
300
250
200
150
100
50
0
1/06
3/06
5/06
6/06
8/06
10/06
12/06
2/07
4/07
6/07
8/07
10/07
12/07
2/08
4/08
6/08
8/08
10/08
12/08
2/09
4/09
Date

Secondary Sedimentation Basin Hydraulic Loading



Waste Activated Sludge (WAS) Loading

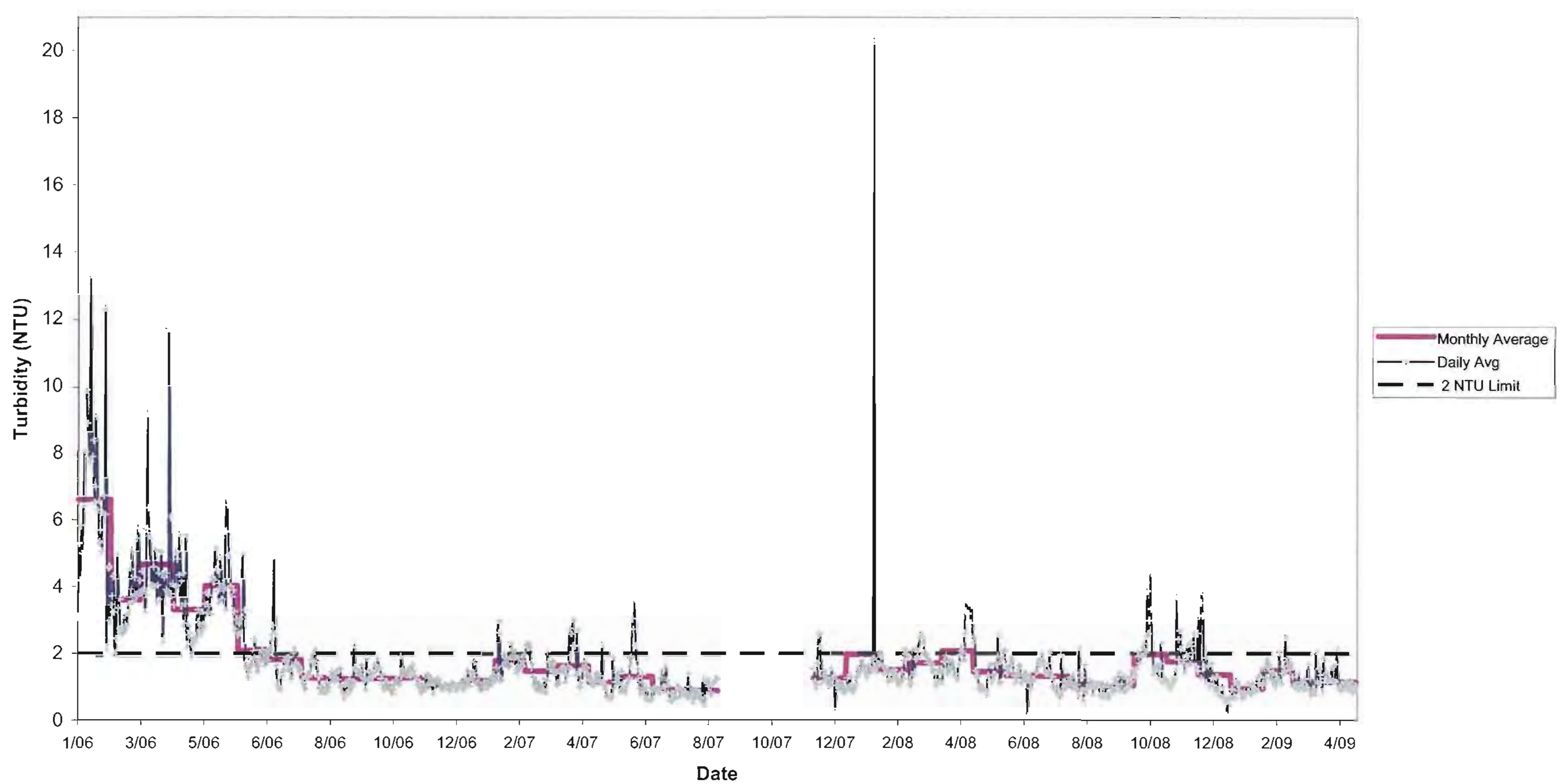




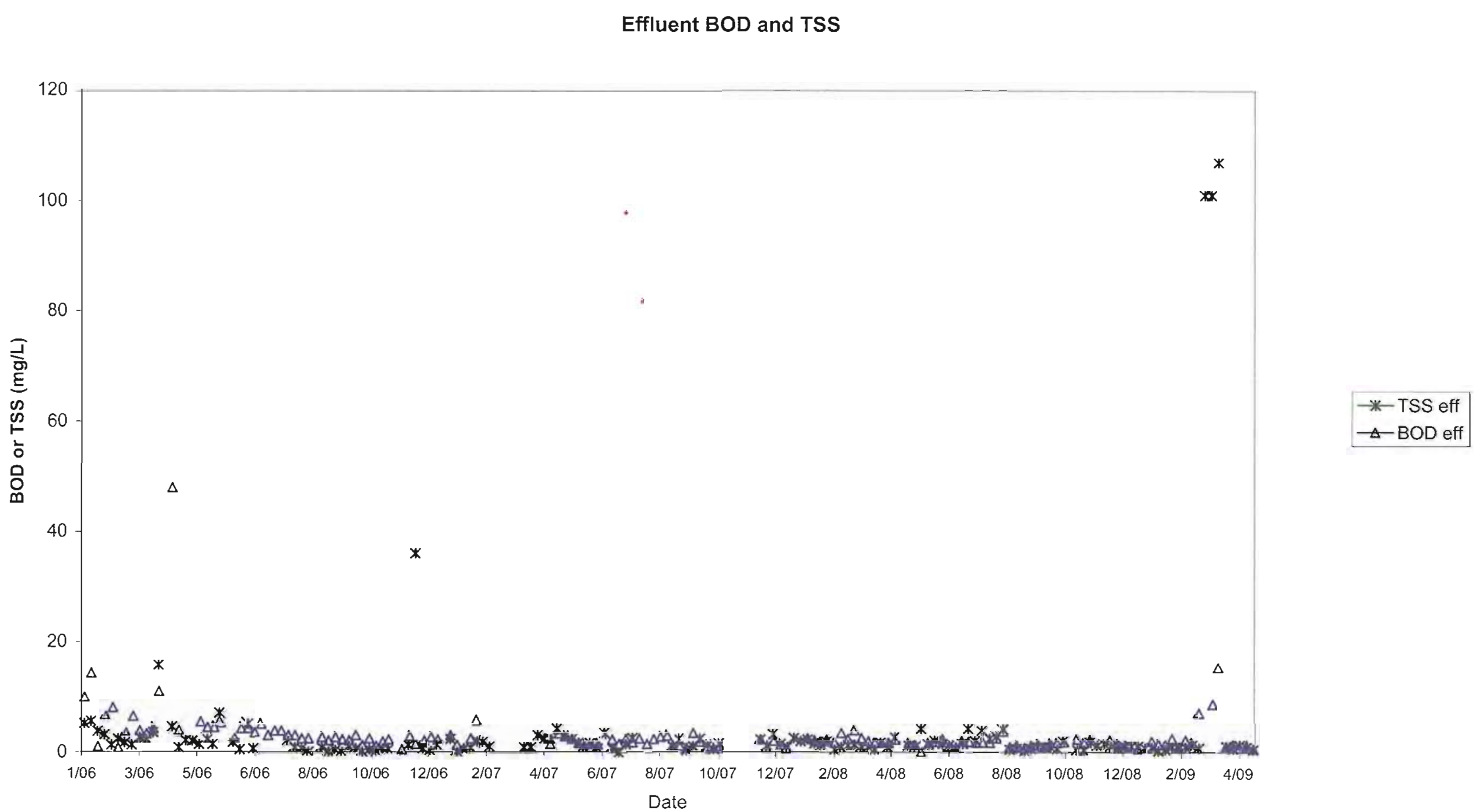
Effluent Nitrogen Compounds
Effluent Nitrogen, mgN/L
30
25
20
15
10
5
0
1/06
3/06
5/06
6/06
8/06
10/06
12/06
2/07
4/07
6/07
8/07
10/07
12/07
2/08
4/08
6/08
8/08
10/08
12/08
2/09
4/09
Date
NO3-N
NH3-N

carollo

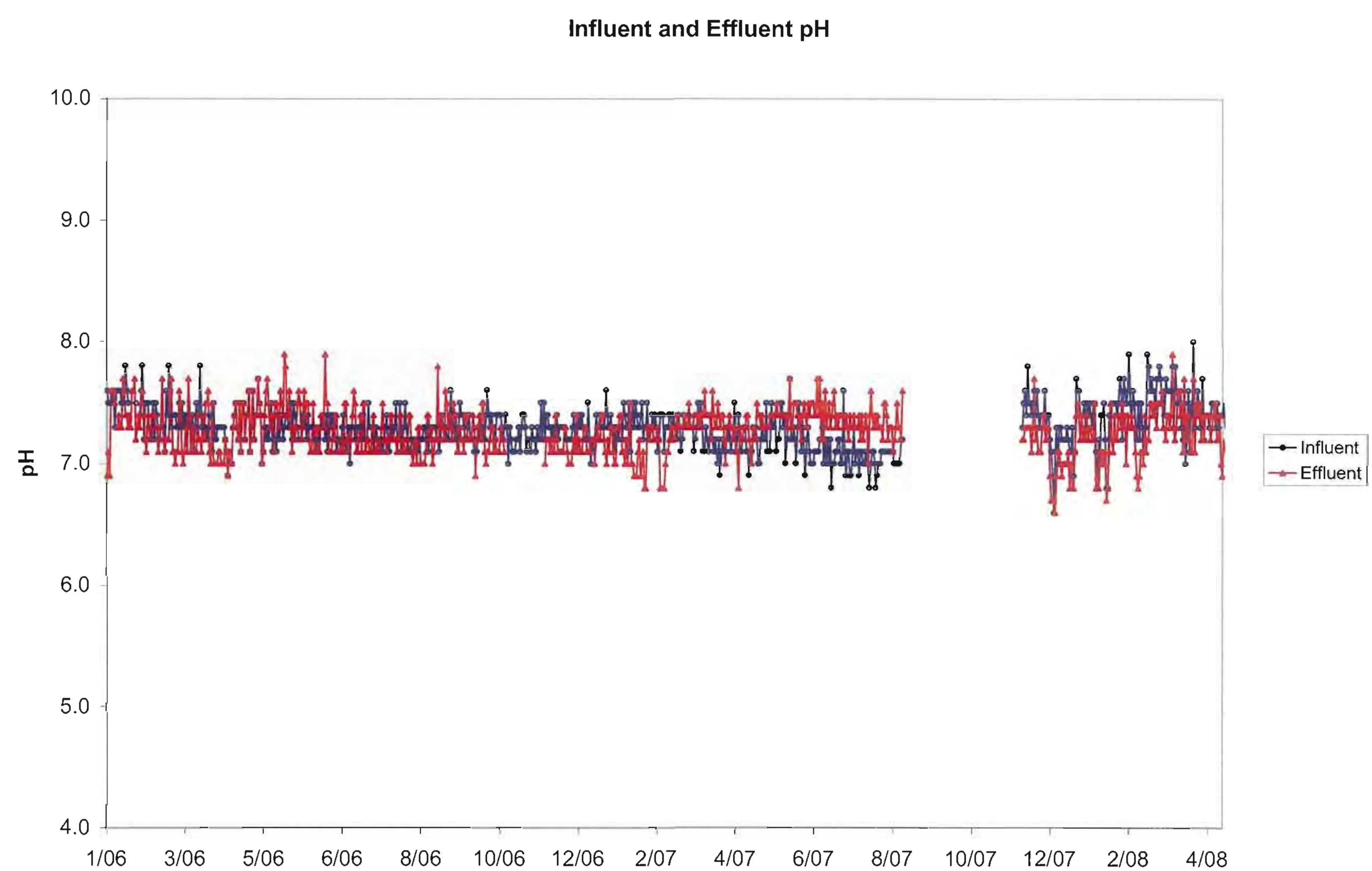
Effluent Turbidity



carollo



Effluent BOD and TSS
BOD or TSS (mg/L)
0
20
40
60
80
100
120
1/06
3/06
5/06
6/06
8/06
10/06
12/06
2/07
4/07
6/07
8/07
10/07
12/07
2/08
4/08
6/08
8/08
10/08
12/08
2/09
4/09
Date
TSS eff
BOD eff



Influent and Effluent pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH
1/06
3/06
5/06
6/06
8/06
10/06
12/06
2/07
4/07
6/07
8/07
10/07
12/07
2/08
4/08
Influent
Effluent

APPENDIX B

LAYER AND SURVEY DATUM REQUIREMENTS

CITY OF PRESCOTT
Everybody's Hometown

PUBLIC WORKS DEPARTMENT
430 N VIRGINIA ST, PRESCOTT, AZ 86302
(928) 777-1130 (F) 928-771-5929

LAYER AND SURVEY DATUM REQUIREMENTS

When submitting survey datum and layer information for engineering plans that are to be submitted to the City of Prescott (i.e.: final plat, preliminary plat and revision of plat, improvement plans for subdivision and commercial site improvements, as-built plans, etc.) those plans must meet the following survey datum and layer requirements:

1. Datum will be in international feet for horizontal and vertical, NAVD 88 for vertical and City of Prescott co-ordinates for horizontal. Please refer to **Exhibit A** titled, "City of Prescott Survey Datum Requirements."

2. A survey block or note listing two on-site points conforming to "City of Prescott Survey Datum Requirements" must be provided. These two points must have a Northing, Easting and a NAVD 88 elevation.

3. Centerline monuments should be a rebar in a hand hole at all PC's, PT's and intersections. Right-of-Way monuments should be a rebar in concrete at PC's, PT's and angle points. See City of Prescott Standard detail 120-1P entitled, "Survey Marker" as published for downloading on the City of Prescott website: http://www.cityofprescott.net/services/

4. Works will be submitted in their entirety in digital electronic format which is compatible with the city's system as follows: CADD-- .DGN (microstation), .DWG (Auto CADD), .DXF (generic) and must conform to the city's layer and feature requirements as published for downloading on the City of Prescott website: http://www.cityofprescott.net/services/

Please direct questions concerning these requirements to:

City of Prescott
Public Works Department
Jon Jahnke
(928) 777-1130
E-mail: jon.jahnke@prescott-az.gov

CITY OF PRESCOTT
Everybody's Hometown

CITY OF PRESCOTT
PUBLIC WORKS DEPARTMENTS
430 N. VIRGINIA ST, PRESCOTT, AZ 86302
(928) 777-1130 (F) 928-771-5929

"EXHIBIT A"

"CITY OF PRESCOTT SURVEY DATUM REQUIREMENTS"			
COORDINATE UNITS:		International Feet	
DISTANCE UNITS:		International Feet	
HEIGHT UNITS:		International Feet	
VERTICAL DATUM:		NAVD 88	
STATE PLANE			
COORDINATE SYSTEM:		US State Plane 1983	
DATUM:		(WGS 84)	
ZONE:		Arizona Central 0202	
GEOID MODEL:		GEOID99 (Conus)	
CITY OF PRESCOTT – CONVERSION FROM STATE PLANE			
NORTHING:		(State Plane x 1.000329975) – 701,456.0090	
EASTING:		(State Plane x 1.000329975) + 69,457.2499	
STATE PLANE – CONVERSION FROM CITY OF PRESCOTT			
NORTHING:		(City of Prescott + 701,456.0090) x 0.999670134	
EASTING:		(City of Prescott – 69,457.2499) x 0.999670134	
EXAMPLE CITY OF PRESCOTT MINGO BASE			
LATITUDE	34°	34'	29.27969" N
LONGITUDE	112°	28'	48.72638" W
HEIGHT	5582.412'		

STATE PLANE	COORDINATES	CITY OF PRESCOTT GRID
NORTHING	1,301,026.703	600,000.0000
EASTING	530,367.742	600,000.0000
ELEVATION	5,673.955'	5,673.955'
Control provided by the City of Prescott will be in the City of Prescott coordinate system.		

INTERNATIONAL FEET & U.S. FEET CONVERSIONS	
U.S. Feet to International Feet	U.S. Feet x 1.00000200
International Feet to U.S. Feet	International feet x 0.99999800

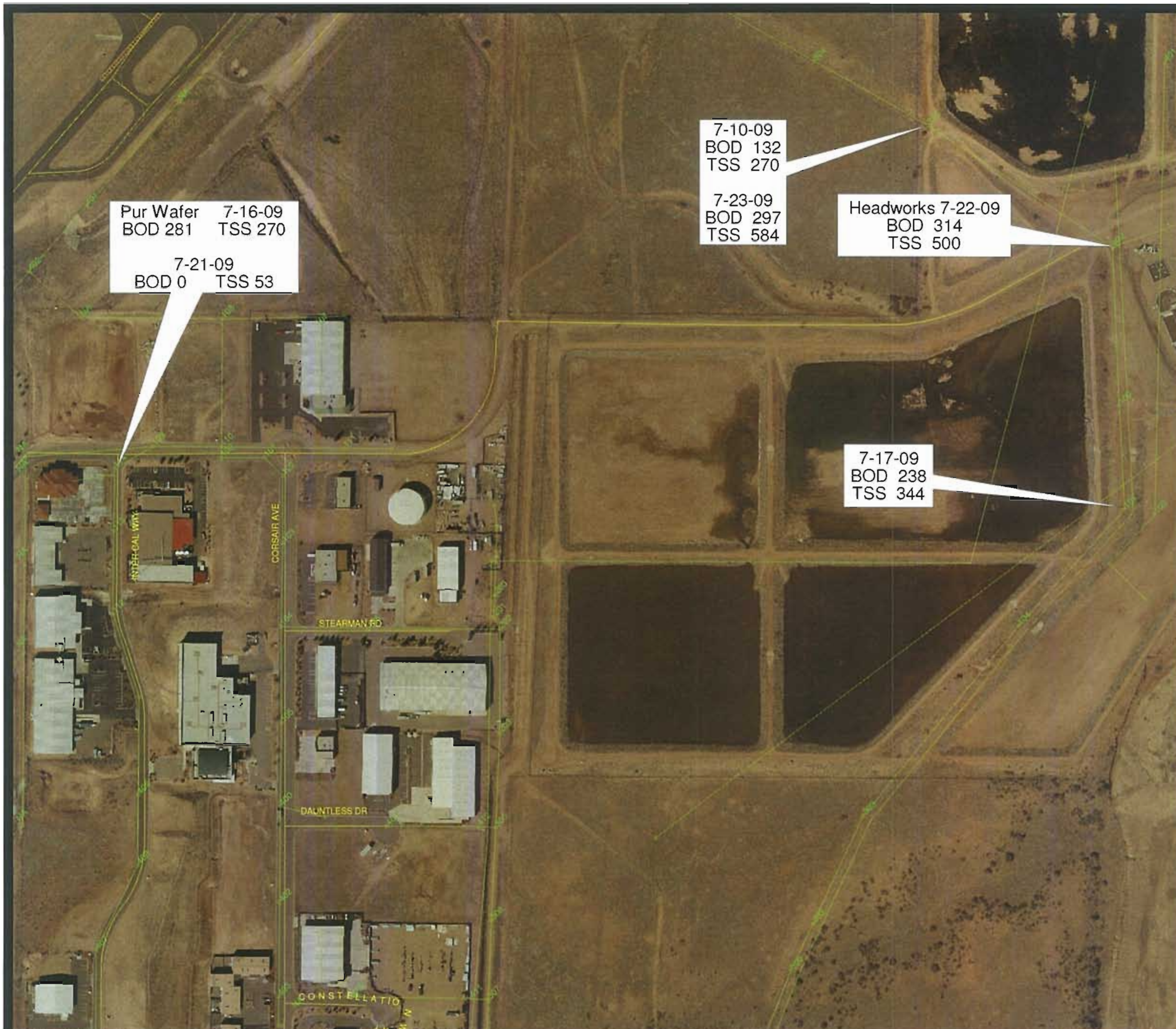
1. When converting elevations, the difference is negligible; 0.011 , For example: 5673.955 International Feet = 5673.944 U.S. Feet.
2. When converting State Plane, the difference is unacceptable:
   Northing: 1,301,026.703 International Feet = 1,301,024.101 U.S. Feet
   Easting: 530,367.742 International Feet = 530,366.681 U.S. Feet
   The difference in coordinates is 2.602 feet in the Northings and 1.061 feet in the Eastings which is a locational difference of 2.810 feet.

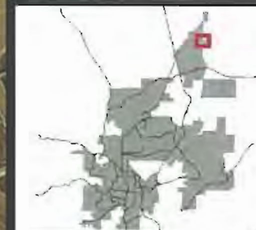
APPENDIX C

DETAILED WASTEWATER SAMPLING RESULTS

AIRPORT WRF
CITY OF PRESCOTT
DETAILED WASTEWATER ANALYSIS RESULTS

	8/18/2009	8/20/2009	8/25/2009	8/28/2009	9/1/2009	9/3/2009	9/8/2009	9/10/2009	**Average**
TSS, mg/L	500	538	1030	374	252	718	436	424	534
Inert TSS, %	12.8	12.3	13.2	12.3	23.8	10.6	11.5	13.7	14
COD									
EFF Unfiltered, mg/L	47	46	62	54	51	52	31	41	48
EFF 0.45micron, mg/L	35	44	60	48	42	48	20	39	42
INF Unfiltered, mg/L	1070	1124	1559	781	454	1219	848	763	977
INF Glass Fiber, mg/L	235	291	205	181	132	185	195	221	206
INF 0.45 micron, mg/L	153	305	161	130	118	148	134	211	170
Alkalinity									
Glass fiber, mg/L	263	259	268	265	246	297	258	347	275
Phosphorus									
Total-Unfiltered, mg/L	32.2	34.2	52.7	27	18.6	35.8	27.4	28.6	32
PO_4- 0.45 micron, mg/L	13	14.3	12.1	11.4	8.9	11.1	12.6	11.1	12
$cBOD_5$									
INF Unfiltered, mg/L	301	462	472	344	181	516	318	251	356
INF Glass Fiber, mg/L	58	106	46	114	110	75	37	34	73
INF 0.45 micron, mg/L	44	99	42.6	50	43	56	30	27	49
TKN									
INF Unfiltered, mg/L	59	53	68	48	39	ND	41	38	49
INF 0.45 micron, mg/L	400	36	33	42	35	36	26	25	79
NH_3-N									
INF 0.45 micron, mg/L	34	33.3	34	34.4	24.6	32.2	27.7	29.2	31





AIRPORT AREA SAMPLING

This map is a product of the The City of Prescott GIS

0' 1" = 393'

scott.gregorio, 2009-08-24 15:35:31
My View

AIRPORT AREA SAMPLING

This map is a product of the The City of Prescott GIS

0' 1" = 401'

scott.gregorio, 2009-08-24 1[illegible]16
My View

This document is a graphic representation only of best available sources. The City of Prescott assumes no responsibility for any errors.

AIRPORT AREA SAMPLING

This map is a product of the The City of Prescott GIS

0' 1" = 426'

scott.gregorio, 2009-08-24 15:25:26
My View

APPENDIX D

PROCESS MODEL OUTPUT

CAROLLO ENGINEERS, PC

W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE

Calc by	Date	Time	Chk by/Date	FileName:
CL	10/08/2009	3:10 PM		Airport WRF Biotran-1402 v5 Final-Print.xls

Biotran-1402	Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
SUMMARY:									
FLOW RATES, mgd:									
- Raw WW Flow		0.98	1.90	1.50	1.20	1.00	1.20	1.80	2.10
- Influent Flow to Activated Sludge		1.08	2.03	1.59	1.27	1.05	1.28	1.92	2.24
INFLUENT WASTEWATER QUALITY, mg/L:									
- BOD, mg/L		341	384	384	384	384	384	384	384
- TSS, mg/L		557	634	634	634	634	634	634	634
- NH3-N, mg/L		30	35	35	35	35	35	35	35
- TKN, mg/L		35	41	41	41	41	41	41	41
SECONDARY EFFLUENT QUALITY, mg/L:									
- BOD (est.), mg/L	2.2	4	6	5	4	3	5	5	5
- TSS (nominal), mg/L		15	15	15	15	15	15	15	15
- NH3-N, mg/L	0.89	0.65	17.05	1.54	0.62	0.43	1.61	1.61	1.62
- NO3-N, mg/L	4.0	4.3	0.0	1.9	3.1	3.4	1.9	1.7	1.6
- NO2-N, mg/L	0.27	0.34	0.13	0.82	0.18	0.11	0.87	0.87	0.87
- T.I.N., mg/L	5.1	5.3	17.2	4.3	3.9	3.9	4.4	4.2	4.1
- Organic N, mg/L	0.9		2.9	2.9	2.8	2.7	2.9	2.9	2.9
- T.N., mg/L	6.0		20.2	7.2	6.7	6.7	7.3	7.1	7.0

CAROLLO ENGINEERS, PC

W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE

Calc by	Date	Time	Chk by/Date	FileName:
CL	10/08/2009	3:10 PM		Airport WRF Biotran-1402 v5 Final-Print.xls

Biotran-1402	Data 2006-2008 Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd	0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
AERATION BASINS								
- # of Anoxic Basins in Service	4	4	4	4	4	4	4	4
- Total Anoxic Volume in Service, MG	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
- Total Aerobic Volume in Service, MG	0.871	1.568	1.568	1.568	1.568	1.568	1.568	1.568
- Total basin volume, MG	1.104	1.802	1.802	1.802	1.802	1.802	1.802	1.802
- Hydraulic Deten. Time, hr	24.5	21.3	27.1	34.1	41.0	33.8	22.5	19.3
- Operating Last-Pass MLSS, mg/L	2,520	2,000	2,530	3,040	3,450	2,000	3,000	3,500
- Design Temperature, deg C	19.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
- Unaerated Volume Fraction	0.21	0.13	0.13	0.13	0.13	0.13	0.13	0.13
- Aerobic SRT, days	8.84	4.67	8.24	13.52	19.70	8.15	8.09	8.07
- Total SRT, days	11.33	5.37	9.48	15.57	22.68	9.39	9.31	9.28
- F/M, lb BOD Appl./lb MLSS-day	0.15	0.23	0.14	0.10	0.07	0.14	0.14	0.14
- Aer. BOD Loading, lb BOD/1000 cf-day	24	29	23	18	15	18	27	32
- ML Recirculation Ratio	1.2	4.2	4.2	4.3	4.3	4.2	4.2	4.2
- Number of surface aerators		7	7	7	7	7	7	7
- Required HP per aerator		40	38	30	25	30	47	56
SECONDARY CLARIFIERS								
- # of Basins	1	1	1	1	1	1	1	1
- # in Service	1	1	1	1	1	1	1	1
- Sec. Clarifier SOR, gpd/sf	369	686	542	433	361	433	650	758
- Sec. Clar. Solids Loading, lb/day-sf	12	16	17	17	17	10	28	43
- Clarifier Safety Factor (CSF)	3.5	2.3	2.3	2.3	2.3	3.6	1.6	1.1
-- CSF Target	3.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3

CAROLLO ENGINEERS, PC

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Biotran-1402

		Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100

DETAILED CALCULATIONS:

RAW WASTEWATER (excluding Recycles)									
o Plant Flow Rate, mgd		1.0	1.9	1.5	1.2	1.0	1.2	1.8	2.1
o Flow Characteristic Ratios									
- Max Month/Annual Avg flow ratio	*	1	1.4	1.4	1.4	1.4	1.4	1.4	1.4
- Peak 4-hr Wet-W Flow/Annual Avg	*	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
- Typical 4-hr Diurnal Peak/Daily Avg	*	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
o Wastewater Characteristics									
- BOD, mg/L, Annual Average	*	341	322	322	322	322	322	322	322
-- Mass Load (lb/d) Peaking Factor	*	1	1.67	1.67	1.67	1.67	1.67	1.67	1.67
-- Effective BOD, mg/L		341	384	384	384	384	384	384	384
"Effective" concentrations correspond to Peak Mass Loads with the flow rate used in the calculation									
- TSS, mg/L, Annual Average	*	557	504	504	504	504	504	504	504
-- Mass Load (lb/d) Peaking Factor	*	1	1.76	1.76	1.76	1.76	1.76	1.76	1.76
-- Effective TSS, mg/L		557	634	634	634	634	634	634	634
- Fpv, VSS fraction	*	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
-- Effective VSS, mg/L		478	544	544	544	544	544	544	544
- NH3-N, mg/L, Annual Average	*	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
-- Mass Load (lb/d) Peaking Factor	*	1	1.67	1.67	1.67	1.67	1.67	1.67	1.67
-- Effective NH3-N, mg/L		29.5	35.2	35.2	35.2	35.2	35.2	35.2	35.2
Organic-N, mg/L, Annual Average	*	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
-- Mass Load (lb/d) Peaking Factor	*	1	1.67	1.67	1.67	1.67	1.67	1.67	1.67
-- Effective Org-N, mg/L		5.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
- NO3-N + NO2-N, mg/L, Annual Average	*		0	0	0	0	0	0	0	0
- Alkalinity, mg/L, Annual Average	*		250	250	250	250	250	250	250	250
- Filterable ("soluble") BOD										
-- fraction, Fbf	*		0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
-- mg/L			72	81	81	81	81	81	81	81
- Fvu, Fraction VSS that is Unbiodeg	*		0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
- Total Phosphorus, mg/L, Annual Averag	*		33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
-- Mass Load (lb/d) Peaking Factor	*		1	1.67	1.67	1.67	1.67	1.67	1.67	1.67
-- Effective Total-P, mg/L			33.0	39.4	39.4	39.4	39.4	39.4	39.4	39.4
-- Fraction filterable ("soluble")	*		0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411
-- Filterable P, mg/L			13.56	16.18	16.18	16.18	16.18	16.18	16.18	16.18
o Design Temperature, deg. C										
- Minimum (Winter)	*		12	12.4	12.4	12.4	12.4	12.4	12.4	12.4
- Maximum (Summer)	*		25	25.5	25.5	25.5	25.5	25.5	25.5	25.5
- Design	*		19.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
ACTIVATED SLUDGE PROCESS										
o Flow Rate, mgd										
- Main-Stream Influent			1.08	2.03	1.59	1.27	1.05	1.28	1.92	2.24
o Influent Characteristics, mg/L										
- Total BOD			312	362	364	365	366	363	362	362
- TSS			528	618	620	622	623	619	618	618
- VSS			449	526	528	529	530	527	526	526
- NH3-N			27	34	33	33	33	33	33	33
- Organic-N			6	7	7	7	7	7	7	7
- NO3-N + NO2-N			0	0	0	0	0	0	0	0
- Alkalinity			239	245	242	242	243	242	242	242

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
- Filterable ("soluble") BOD			65	75	76	76	77	76	76	76
- Fpv, VSS fraction			0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
- AB Influent D.O. Concentration, mg/L			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o Basin dimensions										
- Main Basins - Oxidation Ditch										
-- No. of Basins	*		1	1.80	1.80	1.80	1.80	1.80	1.80	1.80
-- Number of Units in Service	*		1	1.80	1.80	1.80	1.80	1.80	1.80	1.80
-- Liquid Volume per Basin, mil gal			0.871	0.871	0.871	0.871	0.871	0.871	0.871	0.871
- Supplemental Basins or Sections										
-- Identification	*		Anoxic	Anoxic	Anoxic	Anoxic	Anoxic	Anoxic	Anoxic	Anoxic
-- No. of Basins	*		4	4	4	4	4	4	4	4
-- Number of Units in Service	*		4	4	4	4	4	4	4	4
-- Length, ft (inside)	*		25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
-- Width, ft (inside)	*		25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
-- Side Water Depth, ft	*		12	12	12	12	12	12	12	12
-- Volume per Basin, mil gal			0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
o Total Volume of Basins, mil gal										
- Total Basin volume in service			1.104	1.802	1.802	1.802	1.802	1.802	1.802	1.802
- Biological Reaction Volume			1.104	1.802	1.802	1.802	1.802	1.802	1.802	1.802
o Aerated Zone BOD Loading, lb/1,000 cf-day			23.9	28.6	22.7	18.2	15.2	18.1	27.2	31.7
o Hydraulic Detention Time, hr			24.55	21.27	27.11	34.06	41.01	33.83	22.50	19.29
o Selected Operating L-P MLSS, mg/L			2,518	1,997	2,531	3,035	3,447	2,000	3,000	3,500

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
PROCESS LAYOUT										
o Zone Sizes (Fraction of Total Volume)										
- Zone 1	*		0.053	0.065	0.065	0.065	0.065	0.065	0.065	0.065
- Zone 2	*		0.053	0.065	0.065	0.065	0.065	0.065	0.065	0.065
- Zone 3	*		0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 4	*		0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 5	*		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 6	*		0.000	0.435	0.435	0.435	0.435	0.435	0.435	0.435
- Zone 7 (by difference)			0.789	0.435	0.435	0.435	0.435	0.435	0.435	0.435
-- Total			1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
o DO in each Zone (Unaerated, Set = 0), mg/L										
- Zone 1	*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 2	*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 3	*		0.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 4	*		0.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 5	*		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 6	*		2.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8
- Zone 7	*		0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8
o Enhanced Simultaneous Nitrif-Denitrification										
- Apply enhanced SND? Y=1, N=0	*		0	0	0	0	0	0	0	0
o Aerated/Unaerated Fractions										
- Total Unaerated Volume Fraction			0.21	0.13	0.13	0.13	0.13	0.13	0.13	0.13
-- Total Unaerated Volume, mil gal			0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
- Total Aerated Volume Fraction			0.79	0.87	0.87	0.87	0.87	0.87	0.87	0.87
-- Total Aerated Volume, mil gal			0.87	1.57	1.57	1.57	1.57	1.57	1.57	1.57
- Total Aerated Mass Fraction			0.78	0.87	0.87	0.87	0.87	0.87	0.87	0.87

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Plant Influent Flow Routing										
- Fraction to Zone 1	*		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
- Fraction to Zone 2	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Fraction to Zone 3	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Fraction to Zone 4	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Fraction to Zone 5	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Remainder to Zone 6			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Return Sludge Routing										
- Fraction to Zone 1	*		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
- Fraction to Zone 2	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Remainder to Zone 3			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Sludge Wasting Method										
- Wasting from RAS (1) or ML (0)	*		1	1	1	1	1	1	1	1
-- If ML, Waste taken from Zone # (1, 2	*		(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)
o Mixed-Liquor Recirculation (MLR#1) Routing										
- MLR Taken from Zone (0, 1, 2, - - 7); 0=	*		7	7	7	7	7	7	7	7
- MLR Returned to Zone (0, 1, 2, - - 7); 0=	*		3	1	1	1	1	1	1	1
- MLR Flow, mgd			1.25	8.55	6.75	5.40	4.50	5.40	8.10	9.45
- MLR Ratio			1.16	4.21	4.23	4.25	4.27	4.23	4.22	4.22
LOADING CRITERIA										
o BOD Applied, lb/d										
- BOD in Influent			2,813	6,134	4,837	3,864	3,215	3,869	5,804	6,771
- (-) WAS Recycled			36	132	82	49	30	66	99	116
- Net BOD Load			2,777	6,001	4,755	3,815	3,185	3,804	5,705	6,655
o MLSS under aeration, lb			18,284	26,263	33,254	39,851	45,238	26,307	39,385	45,921
- F/M, lb BOD Appl./lb MLSS-day			0.15	0.23	0.14	0.10	0.07	0.14	0.14	0.14

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Organic Loading, Based on Aerated Zone									
- Aerated Volume in Service, 1,000 cf		116	210	210	210	210	210	210	210
- Aer. BOD Loading, lb BOD/1000 cf-day		23.9	28.6	22.7	18.2	15.2	18.1	27.2	31.7
WAS SOLIDS PRODUCTION									
o Solids Production, TSS, lb/d									
- TSS Entering in Feed, lb/d		4,971	10,954	8,626	6,886	5,730	6,901	10,353	12,079
- VSS Change in A.B. Zones		-2,786	-5,105	-4,413	-3,796	-3,312	-3,532	-5,274	-6,141
- ISS Change in A.B. Zones		67	216	148	100	73	119	179	209
- ISS due to Bio-P (Est.), lb/d		0	0	0	0	0	0	0	0
- Unbiodeg VSS due to Bio-P (Est.), lb/d		0	0	0	0	0	0	0	0
- Total Solids Production, lb/d		2,253	6,066	4,361	3,190	2,491	3,488	5,258	6,148
MLSS CHARACTERISTICS									
o Mixed Liquor Components, mg TSS/L (from Final Zone)									
- Solids, mg TSS/L									
-- Slowly Biodegradable		54	80	58	46	37	44	73	87
-- Active Biomass		667	777	830	795	726	659	990	1,156
-- Endogenous Biomass		286	138	262	414	551	206	308	359
-- Ammonia Oxidizers		10	2	9	10	10	7	11	13
-- Nitrite Oxidizers		6	0	4	6	7	3	5	5
-- Unbiodegradable VSS (Influent + Bio-P)		620	412	563	728	874	445	665	775
-- Unbiodegradable VSS from External input		0	0	0	0	0	0	0	0
-- Inorganic SS (influent + Biogrowth)		872	583	798	1,031	1,236	631	943	1,098
-- Inorganic SS in External input		0	0	0	0	0	0	0	0
-- Inorganic SS due to Bio-P (est.)		0	0	0	0	0	0	0	0
-- Total Last-Pass MLSS		2,514	1,992	2,526	3,030	3,442	1,996	2,994	3,493
-- Total Organic-N		106.5	101.3	120.7	133.6	141.3	95.9	143.1	166.7
-- Alkalinity, mg/L as $CaCO_3$		130	184	120	115	113	120	120	121

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Org N fraction of MLVSS (NinVSS)		0.064	0.070	0.069	0.066	0.063	0.069	0.069	0.069
o MLVSS Fraction		0.65	0.71	0.68	0.66	0.64	0.68	0.69	0.69
o BOD of AS Solids									
- BOD/TSS ratio		0.20	0.30	0.24	0.19	0.15	0.24	0.25	0.25
SOLIDS RETENTION TIME, SRT									
o Total Solids Wasted, lb/d		2,253	6,066	4,361	3,190	2,491	3,488	5,258	6,148
- Recycled WAS Solids, lb/d		184	437	323	244	195	259	389	455
- Net lb Solids Yield/day		2,068	5,629	4,038	2,947	2,296	3,229	4,869	5,693
o Total BOD Load, lb/d		2,777	6,001	4,755	3,815	3,185	3,804	5,705	6,655
- Recycled BOD, lb/d		36	132	82	49	30	66	99	116
- Net BOD Load, lb/d		2,741	5,869	4,673	3,766	3,156	3,738	5,606	6,540
o Solids Production									
- lb Dry SS/lb BOD Applied		0.755	0.959	0.864	0.782	0.728	0.864	0.869	0.870
o Total Mass TSS in System, lb		23,432	30,241	38,286	45,873	52,066	30,306	45,325	52,832
- Total SRT (Rs), days		11.33	5.37	9.48	15.57	22.68	9.39	9.31	9.28
o Total Mass TSS in Aerated Zones, lb		18,284	26,263	33,254	39,851	45,238	26,307	39,385	45,921
- Nominal Aerated Mass Fraction		0.780	0.868	0.869	0.869	0.869	0.868	0.869	0.869
- Nominal Aerobic SRT, days		8.84	4.67	8.24	13.52	19.70	8.15	8.09	8.07
o Mass Fraction in Each Zone									
- Zone 1		0.056	0.066	0.066	0.066	0.066	0.066	0.066	0.065
- Zone 2		0.056	0.066	0.066	0.066	0.065	0.066	0.065	0.065
- Zone 3		0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 4		0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 5		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 6		0.000	0.437	0.436	0.436	0.436	0.437	0.436	0.436
- Zone 7		0.780	0.432	0.432	0.433	0.433	0.432	0.433	0.433
		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Min. Aer. SRT recommended for nitrification, days		4.3	8.6	8.6	8.6	8.6	8.6	8.6	8.6
- Washout SRT(total)									
-- Rwashout = 1/(Ua*DOsw - ba)		3.14	5.42	5.42	5.41	5.41	5.42	5.41	5.41
- Recommended Operating SRT									
-- Max recomm. change in NH3, mg/L, for *10% change in SRT*	*	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
-- Max slope criterion, as dNH3/dSRT, mg/L-d		0.54	0.30	0.30	0.30	0.30	0.30	0.30	0.30
-- Recomm. Min. Operating SRT(total)		5.5	9.9	9.9	9.9	9.9	9.9	9.9	9.9
-- Recomm. Min. Op. SRT(Nominal aerobic)		4.3	8.6	8.6	8.6	8.6	8.6	8.6	8.6
-- Nitrification Safety Factor		1.75	1.83	1.83	1.83	1.83	1.83	1.83	1.83
AERATION REQUIREMENTS									
o Oxygen Required, lb/d									
- Net Oxygen Demand in Zone 1		0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 2		0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 3		0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 4		1	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 5		0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 6		0	2,745	3,006	2,762	2,481	2,421	3,559	4,126
- Net Oxygen Demand in Zone 7		2,844	2,416	2,444	2,065	1,764	1,913	2,971	3,507
- Total Oxygen required lb/d		2,845	5,161	5,450	4,827	4,245	4,334	6,530	7,633
o Diffuser Analysis									

Note:

All values of air and blower requirements given below are preliminary estimates, to be refined during detailed design

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Biotran-1402

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Oxygen Transfer Efficiency									
- Diffuser Type		Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
- Aeration Basin D.O. (Avg), mg/L		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
- Design Water Temperature, C		19.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
- Clean Water SOTE	*	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
- Site Conditions Adjustment Factor									
F = Actual / Standard OTE									
-- Alpha factor, including fouling		0.79	0.68	0.75	0.86	0.88	0.76	0.73	0.72
-- Theta factor	*	1.024	1.024	1.024	1.024	1.024	1.024	1.024	1.024
-- Temp. correction, Tau		1.01	1.17	1.17	1.17	1.17	1.17	1.17	1.17
-- Elevation above MSL, ft	*	4,910	4,910	4,910	4,910	4,910	4,910	4,910	4,910
-- ..Pressure correction, Omega		0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
-- Beta factor	*	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
-- Equilibrium C*20		9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07
..Depth Adjustment Factor	*	0	0	0	0	0	0	0	0
- F = Alpha x [Theta ^(T-20)] x (Tau Beta Omega C*20 - C)/C*20		0.39	0.36	0.40	0.46	0.47	0.41	0.39	0.38
- Oxygen Transfer Efficiency		1.08	0.99	1.10	1.27	1.29	1.12	1.08	1.06
OTE = F x SOTE		lb/hp-hr	lb/hp-hr	lb/hp-hr	lb/hp-hr	lb/hp-hr	lb/hp-hr	lb/hp-hr	lb/hp-hr
Preliminary Estimate									
o Surface Aerators		Installed	Installed	Installed	Installed	Installed	Installed	Installed	Installed
- Oxygen to be transferred, lb/hr		119	215	227	201	177	181	272	318
- Aerator hp required		110	216	206	159	137	161	253	301
- Peaking factor	*	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
- Aerator hp Installed		143	281	268	207	178	210	328	391
- Number of aerators		4	7	7	7	7	7	7	7
- Aerator hp per unit		36	40	38	30	25	30	47	56

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
SECONDARY SEDIMENTATION BASINS										
o Flow Rates, mgd										
- AS Influent, Q			1.08	2.03	1.59	1.27	1.05	1.28	1.92	2.24
- Net Sed. Basin Inflow (excl. RAS), Qci			1.08	2.03	1.59	1.27	1.05	1.28	1.92	2.24
- Return Sludge Flow, Qr			0.57	0.61	0.65	0.66	0.65	0.38	1.22	1.90
(not including waste sludge flow)										
- Total Sed Basin Inflow			1.65	2.64	2.25	1.93	1.71	1.66	3.14	4.14
- Total Sed. Basin Underflow			0.61	0.70	0.72	0.71	0.69	0.44	1.31	2.00
- Net Sec. Effluent, Qe			1.04	1.94	1.53	1.23	1.02	1.23	1.84	2.14
o Basin dimensions										
- Group 1	*									
-- No. of Basins	*		1	1	1	1	1	1	1	1
-- Number of Units in Service	*		1	1	1	1	1	1	1	1
-- Diameter, ft (inside)	*		60	60	60	60	60	60	60	60
-- Side Water Depth, ft	*		15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
-- Surface Area per Basin, sf			2,827	2,827	2,827	2,827	2,827	2,827	2,827	2,827
-- Volume per Basin, cf			42,412	42,412	42,412	42,412	42,412	42,412	42,412	42,412
o Surface Overflow Rate										
- Group 1										
-- Surface Area in service, sf			2,827	2,827	2,827	2,827	2,827	2,827	2,827	2,827
-- Surface Overflow Rate, gpd/sf			369	686	542	433	361	433	650	758
o Solids Loading Rate, lb/day-sf										
- Group 1			12	16	17	17	17	10	28	43
o Volume in service, mil gal										
- Group 1			0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Hydraulic Detention Time, hr (based on Q)									
- Group 1		7.1	3.7	4.8	6.0	7.2	6.0	4.0	3.4
o Weir Loading									
- Group 1									
-- Actual weir length per unit, ft	*	179	179	179	179	179	179	179	179
-- Weir loading, gpd/ft		5,819	10,831	8,552	6,843	5,703	6,842	10,263	11,973
o Sludge Settling Characteristics									
ISV = V_0 exp(- MLSS/X_M), ft/h									
- Design Settling Constants									
-- V_0, ft/hr	*	**21.3**	**21.3**	**21.3**	**21.3**	**21.3**	**21.3**	**21.3**	**21.3**
-- X_M, mg/L	*	**2,330**	**2,260**	**2,260**	**2,260**	**2,260**	**2,260**	**2,260**	**2,260**
o Target Settling Values									
- Effluent rise rate (SOR), ft/hr									
-- Group 1		2.05	3.82	3.02	2.41	2.01	2.41	3.62	4.22
- Clarifier Safety Factor, CSF	*	3.23	2.30	2.30	2.30	2.30	2.30	2.30	2.30
- Max. Initial Settling Velocity, ISV, ft/hr		6.6	8.8	7.0	5.6	4.6	5.6	8.3	9.7
- Preferred Max. Last-Pass MLSS, mg/L		2,723	1,997	2,531	3,035	3,447	3,035	2,119	1,771
o Selected Settling Values									
- Operating L-P MLSS conc, mg/L		2,518	1,997	2,531	3,035	3,447	2,000	3,000	3,500
- Operating ISV, ft/h		7.23	8.80	6.95	5.56	4.63	8.79	5.65	4.53
- Operating CSF								CSF<Targ	CSF<Target
-- Group 1		3.52	2.30	2.30	2.30	2.30	3.64	1.56	1.07

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
SLUDGE RETURN AND WASTAGE									
o Wasting Method (see Process Layout)									
- Waste Flow from RAS, Qw		0.037	0.094	0.063	0.044	0.033	0.053	0.084	0.097
o Return Sludge									
- Qr/Q, fraction (based on Qr to Aer Basin*		0.53	0.30	0.41	0.52	0.62	0.30	0.64	0.85
-- [Clarifier Underflow fraction]		0.56	0.35	0.45	0.56	0.65	0.34	0.68	0.89
- RAS flow to Aer Basin, Qr, mgd Average		0.57	0.61	0.65	0.66	0.65	0.38	1.22	1.90
- RAS concentration, mg/L	6,901	6,796	7,462	7,904	8,264	8,552	7,576	7,197	7,237
o Sludge Wastage									
- Total Solids Wasted, lb/d		2,253	6,066	4,361	3,190	2,491	3,488	5,258	6,148
- Adjustment for ESS:									
-- Solids in Effluent, lb/d		130	243	192	153	128	153	230	268
-- Solids in WAS, lb/d	1,778	2,122	5,823	4,169	3,037	2,363	3,334	5,028	5,879
- Concentration, mg/L	6,901	6,796	7,462	7,904	8,264	8,552	7,576	7,197	7,237
- Organic N, lb/d		89	291	197	133	96	158	238	279
- Flow Rate, mgd Average	0.032	0.037	0.094	0.063	0.044	0.033	0.053	0.084	0.097
- Flow Rate, gpd Average	31,754	37,447	93,568	63,250	44,066	33,131	52,774	83,774	97,415
o WAS Characteristics, mg/L									
- Wasting from -		RAS	RAS	RAS	RAS	RAS	RAS	RAS	RAS
- BOD		1,359	2,209	1,932	1,598	1,325	1,855	1,775	1,790
- TSS		6,796	7,462	7,904	8,264	8,552	7,576	7,197	7,237
- VSS		4,439	5,280	5,405	5,452	5,480	5,180	4,931	4,962
- NH3-N		0.7	17.0	1.5	0.6	0.4	1.6	1.6	1.6
- Organic-N		284.6	373.3	373.2	360.6	347.9	358.1	340.9	343.0
- NO3-N + NO2-N		4.3	0.0	1.9	3.1	3.4	1.9	1.7	1.6
- Alkalinity		130	184	120	115	113	120	120	121
- Filterable ("soluble") BOD		1.2	1.3	1.0	0.9	0.8	1.0	1.0	1.0
- Total soluble Organic N		2.0	2.2	2.2	2.2	2.1	2.2	2.2	2.2

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
SECONDARY EFFLUENT										
o Flow Rate										
- Net Secondary Effluent, mgd			1.04	1.94	1.53	1.23	1.02	1.23	1.84	2.14
o Secondary Effluent Quality										
- BOD, mg/L			4	6	5	4	3	5	5	5
- TSS (nominal), mg/L	*		15	15	15	15	15	15	15	15
- VSS, mg/L			9.8	10.6	10.3	9.9	9.6	10.3	10.3	10.3
- NH3-N, mg/L			0.7	17.0	1.5	0.6	0.4	1.6	1.6	1.6
- Total Organic N, mg/L			2.6	2.9	2.9	2.8	2.7	2.9	2.9	2.9
- NO3-N, mg/L			4.3	0.0	1.9	3.1	3.4	1.9	1.7	1.6
- NO2-N, mg/L			0.3	0.1	0.8	0.2	0.1	0.9	0.9	0.9
- Alkalinity, mg/L			130	184	120	115	113	120	120	121
- Soluble Organic N, mg/L			2.0	2.2	2.2	2.2	2.1	2.2	2.2	2.2
- T.I.N., mg/L			5.3	17.2	4.3	3.9	3.9	4.4	4.2	4.1
- Total N, mg/L			7.9	20.2	7.2	6.7	6.7	7.3	7.1	7.0
TERTIARY FILTRATION			In Service	In Service	In Service	In Service	In Service	In Service	In Service	In Service
o Tertiary Filtration in Service? (Y=1, N=0)	*		1	1	1	1	1	1	1	1
o Influent										
- Flow, mgd										
-- Total			1.0	1.9	1.5	1.2	1.0	1.2	1.8	2.1
- BOD, total, mg/L			4.0	6.0	5.0	4.0	3.0	5.0	5.0	5.0
- SS, total, mg/L			15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
o Filter Area										
- Surface Area per Filter, sf	*		575	575	575	575	575	575	575	575
- Backwash - Continuous (0) or Intermitte	*		0	0	0	0	0	0	0	0
- Number of Filters										
-- Total			1	1	1	1	1	1	1	1
- Number of Units in Service			1	1	1	1	1	1	1	1

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Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Filter Loading										
- Equalization provided? (Y=1, N=0)	*		0	0	0	0	0	0	0	0
- Peaking factor (peak day)	*		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
- Surface Area in Service, sf			575	575	575	575	575	575	575	575
- Liquid Loading Rate, gpm/sf										
-- At Daily Average Flow, gpm/sf			1.3	2.3	1.8	1.5	1.2	1.5	2.2	2.6
-- At Peak Day Flow, gpm/sf			2.5	4.7	3.7	3.0	2.5	3.0	4.4	5.2
o Removal										
- SS Removal, %	*		60	60	60	60	60	60	60	60
- SS removed, lb/d			78	146	115	92	77	92	138	161
- BOD removed, lb/d			15	46	31	19	11	25	37	42
o Backwash Flow										
- Percent of Flow, %	*		2	2	2	2	2	2	2	2
- Backwash Flow, mgd			0.02	0.04	0.03	0.02	0.02	0.02	0.04	0.04
o Backwash Characteristics, mg/L										
- BOD			86	143	121	95	67	122	120	120
- TSS			450	450	450	450	450	450	450	450
- VSS			294	318	308	297	288	308	308	309
- NH3-N			0.7	17.0	1.5	0.6	0.4	1.6	1.6	1.6
- Organic-N			21	25	23	22	20	23	23	23
- NO3-N + NO2-N			4.7	0.2	2.7	3.2	3.5	2.8	2.6	2.5
- Alkalinity			130	184	120	115	113	120	120	121
o Net Flow to Disinfection, mgd										
- Undisinfected Plant Water Used	*		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- To Disinfection			1.02	1.90	1.50	1.20	1.00	1.20	1.80	2.10

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Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Tertiary Effluent Quality, mg/L									
- BOD	2.2	2.3	3.2	2.6	2.1	1.7	2.6	2.6	2.6
- SS	1.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
- VSS, mg/L		3.9	4.2	4.1	4.0	3.8	4.1	4.1	4.1
- NH3-N, mg/L	0.89	0.7	17.0	1.5	0.6	0.4	1.6	1.6	1.6
- Total Organic N, mg/L	0.86	2.2	2.5	2.5	2.4	2.4	2.5	2.5	2.4
- NO3-N + NO2-N, mg/L	4.25	4.7	0.2	2.7	3.2	3.5	2.8	2.6	2.5
- Alkalinity, mg/L		130	184	120	115	113	120	120	121
- Filterable ("soluble") BOD		1.2	1.3	1.0	0.9	0.8	1.0	1.0	1.0
- Soluble Organic N, mg/L		2.0	2.2	2.2	2.2	2.1	2.2	2.2	2.2
- T.I.N., mg/L		5.3	17.2	4.3	3.9	3.9	4.4	4.2	4.1
- Total N, mg/L		7.5	19.7	6.7	6.3	6.3	6.8	6.7	6.6
FINAL EFFLUENT									
o Flow Rate, mgd									
- Plant Water used	*	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01
- Final Effluent Flow		0.98	1.89	1.49	1.19	0.99	1.19	1.79	2.09
RESIDUALS MANAGEMENT									
SOLIDS GENERATED									
o Total Waste Activated Sludge									
- Flow, mgd		0.037	0.094	0.063	0.044	0.033	0.053	0.084	0.097
- Solids, lb/d		2,122	5,823	4,169	3,037	2,363	3,334	5,028	5,879
- Concentration, %		0.68	0.75	0.79	0.83	0.86	0.76	0.72	0.72
- VSS, %		65	71	68	66	64	68	69	69
- Volatile solids, lb/d		1,386	4,120	2,851	2,004	1,514	2,280	3,445	4,032
- Organic N, lb/d		89	291	197	133	96	158	238	279

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Biotran-1402	Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
SLUDGE ROUTING									
o Waste Activated Sludge									
- (a) Thickening		None	None	None	None	None	None	None	None
- (b) Then routed to - -		Dewatering	Dewaterinç	Dewaterinç	Dewaterinç	Dewatering	Dewaterinç	Dewaterinç	Dewatering
FEED TO DEWATERING									
o Dewatering Process		Belt Pr	Centrif	Centrif	Centrif	Centrif	Centrif	Centrif	Centrif
o Flow rate, mgd									
- WAS, Direct or Thickened		0.037	0.094	0.063	0.044	0.033	0.053	0.084	0.097
o Total Solids, lb/d									
- WAS, Direct or Thickened		2,122	5,823	4,169	3,037	2,363	3,334	5,028	5,879
o VSS, lb/d									
- WAS, Direct or Thickened		1,386	4,120	2,851	2,004	1,514	2,280	3,445	4,032
o Organic N in VSS, lb/d									
- WAS, Direct or Thickened		88	290	196	132	96	157	237	277
o Soluble Characteristics, mg/L									
- WAS, Direct or Thickened									
-- NH3-N		0.7	17.0	1.5	0.6	0.4	1.6	1.6	1.6
-- NO3-N + NO2-N		4	0	2	3	3	2	2	2
-- Alkalinity		130	184	120	115	113	120	120	121
-- Filterable ("soluble") BOD		1	1	1	1	1	1	1	1
-- Soluble Organic N		2	2	2	2	2	2	2	2

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W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE

Calc by	Date Time	Chk by/Date	FileName:
CL	10/08/2009 3:10 PM		Airport WRF Biotran-1402 v5 Final-Print.xls

Biotran-1402		Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
BELT PRESS OR GRAVITY BELT DEWATERING			Belt Pr	NA	NA	NA	NA	NA	NA	NA
o Sludge Feed										
- Flow rate, mgd			0.037							
- Total Solids, lb/d			2,122							
- Total VSS, lb/d			1,386							
o Number of Presses (2m)	*		1							
- Number of Units in Service	*		1							
- Feed Rate, gpm per unit	*		100							
- Operating cycle										
-- days/week	*		5							
-- hours/day (calc)			8.7							
o Sludge Cake										
- Capture, %	*		95							
- Concentration, %	*	8.70	8.7							
- Cake Solids, lb/d										
-- Dry Solids, lb/d			2,016							
-- Wet Cake, tons/d			11.6							
- Flow, mgd			0.0028							
o Filtrate										
- Filtrate Flow, mgd			0.035							
- Characteristics, mg/L										
-- BOD			1							
-- TSS	*		250							
-- VSS			163							
-- NH3-N			1							
-- Organic-N			10							
-- NO3-N + NO2-N			4							
-- Alkalinity			130							

CAROLLO ENGINEERS, PC

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Biotran-1402	Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Wash Water									
- Wash water, mgd/mgd feed	*	1.00							
-- Wash Water flow, mgd		0.037							
- Solids in Wash Water									
-- Unrecovered Solids, lb/d		106							
-- Solids in Filtrate		72							
-- Solids in Wash Water, lb/d		34							
-- TSS in Wash Water, mg/L		108							
- Characteristics, mg/L									
-- BOD		1							
-- TSS		108							
-- VSS		71							
-- NH3-N		0.7							
-- Organic-N		6							
-- NO3-N + NO2-N		4.7							
-- Alkalinity		130							
-- Filterable ("soluble") BOD		1.2							
-- Total soluble Organic N		2.0							
o Belt Press Combined Filtrate & Wash Water									
- Flow, mgd									
-- Filtrate		0.035							
-- Wash Water		0.037							
-- Total		0.072							
- Characteristics, mg/L									
-- BOD		1							
-- TSS		176							
-- VSS		115							

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W.O./CLIENT: 8286A.00 / City of Prescott
PROJECT: Airport WRF - Capacity Evaluation
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Calc by: CL | Date Time: 10/08/2009 3:10 PM | Chk by/Date: | FileName: Airport WRF Biotran-1402 v5 Final-Print.xls

Biotran-1402

		Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd			0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
-- NH3-N			1							
-- Organic-N			8							
-- NO3-N + NO2-N			4							
-- Alkalinity			130							
-- Filterable ("soluble") BOD			1							
-- Total soluble Organic N			2.0							
CENTRIFUGE DEWATERING			NA	In Service	In Service	In Service	In Service	In Service	In Service	In Service
o Sludge Feed										
- Flow Rate, mgd				0.094	0.063	0.044	0.033	0.053	0.084	0.097
- Total Solids, lb/d				5,823	4,169	3,037	2,363	3,334	5,028	5,879
- Total VSS, lb/d				4,120	2,851	2,004	1,514	2,280	3,445	4,032
o Number of Centrifuges	*			1	1	1	1	1	1	1
- Number of Units in Service				1	1	1	1	1	1	1
- Feed Rate, gpm per unit	*			100	100	100	100	100	100	100
- Operating cycle										
-- days/week	*			6	6	6	6	6	6	6
-- hours/day (calc)				18.2	12.3	8.6	6.4	10.3	16.3	18.9
o Sludge Cake										
- Capture, %	*			95	95	95	95	95	95	95
- Concentration, %	*			20.0	20.0	20.0	20.0	20.0	20.0	20.0
- Cake Solids, lb/d										
-- Dry Solids, lb/d				5,532	3,961	2,885	2,245	3,168	4,777	5,585
-- Wet Cake, tons/d				13.8	9.9	7.2	5.6	7.9	11.9	14.0
- Flow, mgd				0.0033	0.0024	0.0017	0.0013	0.0019	0.0029	0.0033

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W.O./CLIENT: 8286A.00 / City of Prescott
PROJECT: Airport WRF - Capacity Evaluation
SUBJECT: PROCESS ANALYSIS AND MASS BALANCE

Calc by: CL | Date Time: 10/08/2009 3:10 PM | Chk by/Date: | FileName: Airport WRF Biotran-1402 v5 Final-Print.xls

Biotran-1402

	Data 2006-2008	Calibration	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifie controlling	Design MMADF Winter Sec. Clarifier controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling	Design MMADF Winter Ox. Ditches controlling
Design (Max-Month) Flow, mgd		0.984	1.900	1.500	1.200	1.000	1.200	1.800	2.100
o Dewatering Centrate									
- Flow, mgd			0.090	0.061	0.042	0.032	0.051	0.081	0.094
- Characteristics, mg/L									
-- BOD			1	1	1	1	1	1	1
-- TSS			387	411	430	446	393	373	375
-- VSS			274	281	284	286	269	255	257
-- NH3-N			17	2	1	0	2	2	2
-- Organic-N			21	21	21	20	21	20	20
-- NO3-N + NO2-N			0	2	3	3	2	2	2
-- Alkalinity			184	120	115	113	120	120	121

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 4
Influent and Effluent Management

Final

In Association with

Project No. 164890

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City of Prescott

TECHNICAL MEMORANDUM
NO. 4
INFLUENT AND EFFLUENT MANAGEMENT

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ES4 TM 4 – INFLUENT AND EFFLUENT MANAGEMENT

ES4.1 Introduction

The main objectives of this technical memorandum (TM) are to (1) address the relative effectiveness of infiltration/inflow (I/I) reduction in the collection system versus the extent of treatment plant expansions to accommodate increased flows due to I/I, and (2) address issues related to existing and future effluent management.

ES4.2 Influent Management

Site master planning at the City's wastewater treatment facilities requires the establishment of design flow peaking factors for the purpose of unit process sizing. The peak hour flows recently observed at the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF) exceed typical peaking factor values of 2 to 3 observed in other communities of similar size.

The City of Prescott Wastewater Collection System Model Study (Carollo, January 2008) identified significant amounts of I/I entering the wastewater collection system as a result of storm events. Based on 2004-2005 information, approximately 25-28 percent of the annual flow received at the Sundog WWTP appears to be I/I, and the I/I contribution to the Airport WRF annual flow is approximately 9-13 percent.

A detailed analysis of influent flow records at the Sundog WWTP and the Airport WRF was performed in order to quantify the immediate flow equalization needs at both facilities. Both facilities experienced significant peak flows during storm events in January 2010. The analysis of Sundog WWTP influent flows is presented in Figure ES4.1. The analysis of the Airport WRF influent flows is presented in Figure ES4.2.

The proposed strategy for handling storm flows at the Sundog WWTP is to plan influent flow equalization facilities for the short and medium term using new tankage for a recommended volume of 9 million gallons (MG). While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the recommended volume includes a reasonable safety factor of 1.2 (industry standard) over the equalization volume of 7.6 MG estimated based on the 2010 storm event.

The proposed strategy for handling storm flows at the Airport WRF is to plan influent flow equalization facilities for the short and medium term using the existing oxidation ditch basins. The existing oxidation ditches will not be utilized for secondary treatment in the Airport WRF Phase 1 capacity improvements, and they will become available for flow equalization when the new Phase 1 aeration basins are completed. The total available volume of the two existing oxidation ditch basins (1.57 MG) provides a safety factor of 2.2

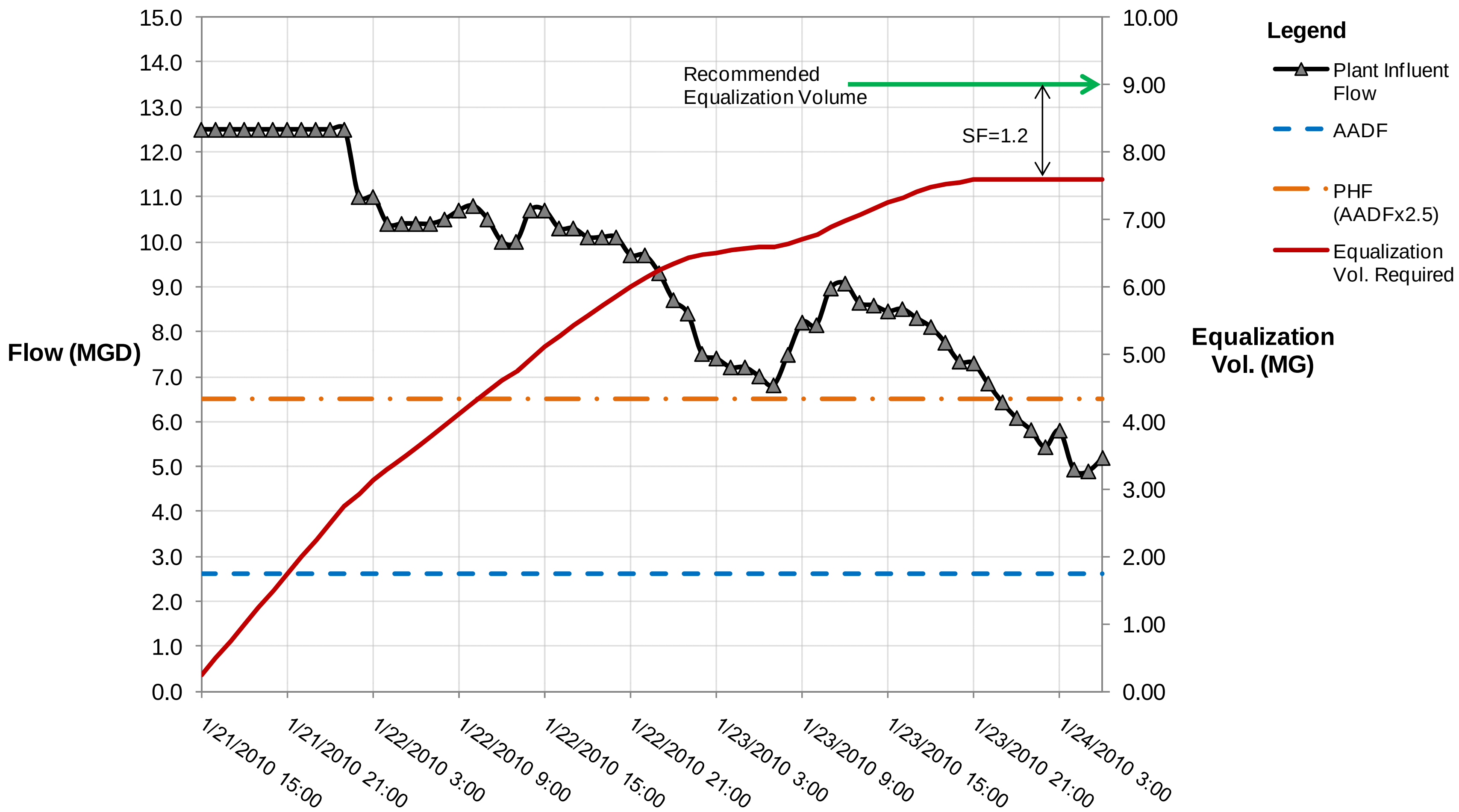
over the equalization volume of 0.7 MG estimated based on the 2010 storm event. While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the existing total oxidation ditch volume provides a reasonable safety factor over the calculated required volume.

ES4.3 Effluent Management

In support of the safe yield goal and based on the City's "Water Management Policy" (adopted October 2005), the City utilizes 100 percent of the effluent from its two treatment facilities, including a portion for reuse (golf course irrigation, commercial, and other) and the remaining amount for groundwater recharge. During 2010 about 67% of the recharge water was from Sundog WWTP and 33% was from Airport WRF. About 72% of the treated effluent was recharged and 28% was used for otherwise

The City's existing recharge facility at the Airport WRF site is permitted for 4.4 mgd (annual average) and the City has contract commitments for approximately 2.0 mgd (annual average) of effluent to outside customers. With existing total effluent flows (Sundog WWTP and Airport WRF) at approximately 3.7 mgd, the City has available capacity to continue reclaiming 100 percent of their effluent in the short term. However, it is important for the City to develop a reclaimed water master plan to accommodate future increased effluent flows.

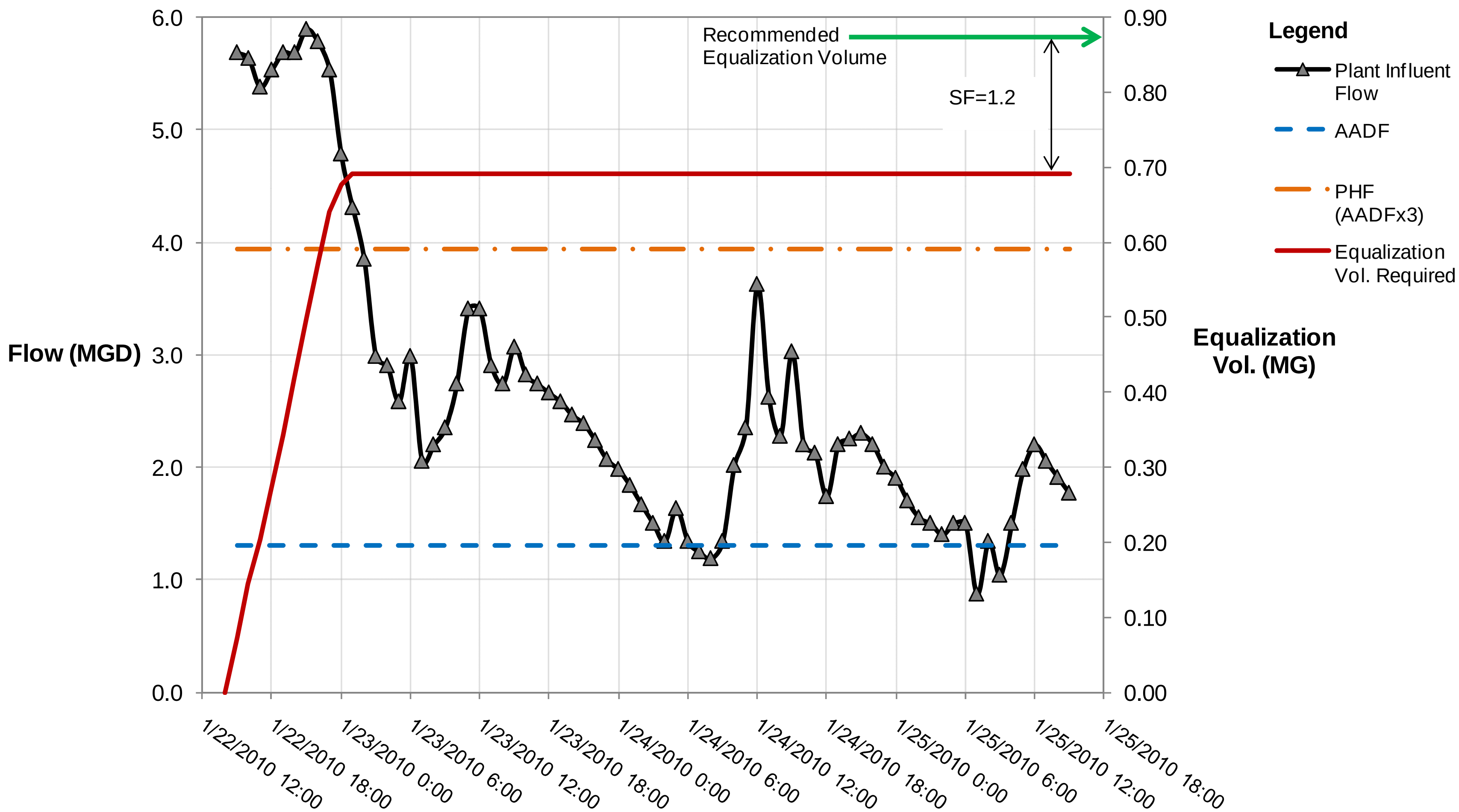
The recommended reclaimed water master plan should comprehensively address both physical and administrative aspects of effluent management. Two major factors that contribute to the need for the reclaimed water master plan are: 1) The proposed Phase 1 expansion of the Airport WRF to 3.75 mgd will require documentation of compatible effluent management facilities; and 2) The reclaimed water master plan will have to address issues such as annual water balance, given the potential seasonal variations of effluent reuse through outside contracts. Although the City may have contract commitments to provide effluent for irrigation, it may be the City's responsibility to provide "backup" effluent disposal for seasonal and/or wet weather conditions.



SUNDOG WWTP FLOW EQUALIZATION ANALYSIS

FIGURE ES4.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT



AIRPORT WRF FLOW EQUALIZATION ANALYSIS

FIGURE ES4.2

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT

Technical Memorandum No. 4

1.0 INTRODUCTION

This technical memorandum (TM) was developed primarily to address the relative effectiveness of infiltration/inflow (I/I) reduction in the collection system versus the extent of treatment plant expansions to accommodate increased flows due to I/I. Major issues related to existing and future effluent management are also included in this TM.

As detailed in the City of Prescott's (City's) Wastewater Collection System Model Study (2008 System Study) (Carollo, January 2008), I/I is a major issue for the City's wastewater collection and treatment systems. Wastewater flows into the City's two treatment facilities (Sundog WWTP and Airport WRF) increase significantly in the days following storm events.

The City of Prescott proactively manages the effluent from its two wastewater treatment facilities as an integral component of the City's overall water resources portfolio. All of the effluent from the two treatment plants is reclaimed, either for suitable reuse applications (i.e., golf course irrigation and construction materials washing) or for groundwater recharge.

2.0 INFLUENT MANAGEMENT

As part of the Sundog WWTP and Airport WRF master planning efforts, it was important for the City to assess the magnitude of existing I/I flows and their effect on the future planning of wastewater treatment facilities. This section summarizes recent efforts to quantify I/I in the collection system, as well current effects of I/I flows at the two wastewater treatment facilities. Based on this information, a recommended approach to managing I/I flows is presented, taking into account critical needs and budgetary priorities as identified in the Sundog WWTP and Airport WRF master planning project.

2.1 Previous and Existing Plant Influent Flow Conditions

The last major capacity expansion design for the Sundog WWTP was completed in 1990. The design and observed peaking factors used for the last major plant expansion are summarized in. The observed flow peaking factors between 2006 and 2009 have exceeded the original design peaking factors, as summarized in Technical Memorandum No. 3S. Peak hour flows of up to 12.5 mgd have been recently observed at the Sundog WWTP, which represent 83 percent of the design peak hour flow of 15 mgd used for the 1989 expansion design.

The last major capacity expansion design for the Airport WRF was completed in 1998. The design and observed peaking factors used for the last major expansion are also summarized in Table 4.1. The observed peak day and peak hour flow peaking factors between 2006 and 2009 are in line with the original design peaking factors, as summarized in Technical Memorandum No. 3A. However, in a recent storm flow event in early 2010, the observed peak hour factor exceeded previous design values. Peak hour flows of up to 4.5 mgd were observed at the Airport WRF, which exceeded the existing peak flow capacity of some unit processes in the plant.

**Table 4.1 Previous Design and Observed Hydraulic Peaking Factors
Technical Memorandum No. 4 – Influent and Effluent Management
City of Prescott, Arizona**

	Sundog WWTP (Peaking Factor)		Airport WRF (Peaking Factor)	
Peaking Factor	1989 Design	Observed	1998 Design	Observed
Maximum Month Average Day	1.08	2.0 (1)	1.2	1.4 (1)
Peak Day	2.0	3.3 (1)	2.0	2.0 (1)
Peak Hour	2.5	4.8 (2)	3.0	4.5 (2)

Notes:
(1) Based on 2006-2009 plant flow data.
(2) Includes January 2010 storm event.

Site master planning at the two wastewater treatment facilities requires the establishment of design flow peaking factors for the purpose of unit process sizing. The peak hour flows recently observed at the two Prescott wastewater treatment facilities exceed typical peaking factor values of 2 to 3 observed in other communities of similar size. The analysis presented in the following subsections presents a recommended approach for managing influent wastewater flows at the City of Prescott.

2.2 Infiltration and Inflow

As previously noted, the 2008 System Study identified significant amounts of I/I entering the wastewater collection system as a result of storm events. Daily inflows and monthly precipitation records were summarized and compared for the Sundog and Airport treatment plants using 2004 and 2005 data (Table 4.2 and Table 4.3). Notwithstanding seasonal variations, data in these tables indicate the presence of I/I for both plants. For example, the maximum daily inflow to the Airport WRF (2.058 MG) occurred in December along with the second highest monthly precipitation in 2004.

Table 4.2 Daily Inflows vs. Precipitation for the Sundog WWTP
Technical Memorandum No. 4 – Influent and Effluent Management [1]
City of Prescott

Year-Month	% Complete[2]	Daily Inflow (mgd) Low Day	Average Day	Max Day	Precipitation[3] (inches)
January-04	0%	-	-	-	0.56
February-04	0%	-	-	-	1.32
March-04	0%	-	-	-	1.61
April-04	0%	-	-	-	1.82
May-04	0%	-	-	-	0.00
June-04	100%	1.845	1.959	2.111	0.00
July-04	97%	1.820	2.553	3.303	3.29
August-04	87%	1.260	2.506	2.830	1.16
September-04	97%	1.934	2.321	3.080	1.11
October-04	87%	1.974	2.610	4.261	4.24
November-04	93%	2.930	4.087	6.658	3.52
December-04	84%	2.370	3.449	8.975	3.41
2004	**54%**	**1.260**	**2.762**	**8.975**	**22.02**
January-05	19%	4.762	7.000	9.067	4.85
February-05	50%	4.717	5.549	6.627	5.28
March-05	90%	2.285	3.352	4.332	1.23
April-05	97%	2.516	3.092	3.828	1.37
May-05	90%	2.217	2.690	3.485	0.00
June-05	100%	1.890	2.192	2.802	0.36

Table 4.2	Daily Inflows vs. Precipitation for the Sundog WWTP Technical Memorandum No. 4 – Influent and Effluent Management [(1)] City of Prescott				
	%	Daily Inflow (mgd)			Precipitation[(3)]
Year-Month	Complete[(2)]	Low Day	Average Day	Max Day	(inches)
July-05	100%	1.750	2.178	2.952	2.06
August-05	100%	2.318	3.016	3.810	3.20
September-05	93%	2.122	2.413	3.111	0.48
October-05	0%	-	-	-	0.83
November-05	0%	-	-	-	0.04
December-05	0%	-	-	-	0.00
2005	**62%**	**1.750**	**2.993**	**9.067**	**19.69**

Notes:
(1) Analysis from Wastewater Collection System Model Study (Carollo, January 2008).
(2) Indicates the percentage of days with data available for the given month.
(3) Based on daily precipitation records from the following rain gauges: ·
Sundog WWTP: Haisley Water Tank, Bannon Creek, Prescott Heights, Thumb Butte Tank

Table 4.3	Daily Inflows vs. Precipitation for the Airport WRF Technical Memorandum No. 4 – Influent and Effluent Management [(1)] City of Prescott				
	%	Daily Inflow (mgd)			Precipitation[(3)]
Year-Month	Complete[(2)]	Low Day	Average Day	Max Day	(inches)
January-04	100%	0.630	0.702	0.775	0.44
February-04	100%	0.674	0.708	0.821	0.66
March-04	100%	0.650	0.720	0.801	0.39
April-04	100%	0.695	0.783	1.040	1.45
May-04	100%	0.601	0.684	0.750	0.00
June-04	100%	0.634	0.667	0.707	0.00
July-04	100%	0.613	0.673	0.745	1.37
August-04	100%	0.492	0.682	0.723	1.04
September-04	100%	0.663	0.701	0.819	0.62
October-04	0%	-	-	-	3.11
November-04	100%	0.769	0.924	1.333	2.43
December-04	100%	0.767	0.922	2.058	2.96
2004	**92%**	**0.492**	**0.742**	**2.058**	**14.44**
January-05	0%	-	-	-	3.90
February-05	0%	-	-	-	3.54
March-05	0%	-	-	-	0.92
April-05	0%	-	-	-	1.23

Table 4.3	Daily Inflows vs. Precipitation for the Airport WRF Technical Memorandum No. 4 – Influent and Effluent Management [1] City of Prescott				
	%	Daily Inflow (mgd)			Precipitation[3]
Year-Month	Complete[2]	Low Day	Average Day	Max Day	(inches)
May-05	0%	-	-	-	0.00
June-05	100%	0.629	0.793	1.084	0.81
July-05	100%	0.688	0.750	1.014	1.77
August-05	84%	0.797	0.992	1.472	3.17
September-05	0%	-	-	-	0.28
October-05	0%	-	-	-	0.81
November-05	0%	-	-	-	0.08
December-05	0%	-	-	-	0.00
2005	**24%**	**0.629**	**0.837**	**1.472**	**16.50**

Notes:

(1) Analysis from Wastewater Collection System Model Study (Carollo, January 2008).

(2) Indicates the percentage of days with data available for the given month.

(3) Based on daily precipitation records from the following rain gauges: ·
Airport WRF: Granite Basin, Prescott Heights, Watson Lake, Yavapai County Public Works Yard

Table 4.4 summarizes the results of the I/I analysis on an annual basis for the two treatment plants. Approximately 25-28 percent of the annual flows received at the Sundog WWTP appear to be I/I, and the I/I contribution to the Airport WRF annual flows is approximately 9-13 percent. When comparing I/I at the two treatment plants, it is important to note that not only the percentage of I/I flows is higher at the Sundog WWTP, but also the magnitude of the I/I flows is significantly larger than I/I at the Airport WRF. In 2005, approximately 0.77 mgd was due to I/I at the Sundog WWTP, whereas the I/I contribution at Airport was 0.11 mgd. This comparison shows the importance of focusing I/I reduction efforts in the Sundog WWTP service area first.

Table 4.4	Summary of Annual Wet/Dry Flows Technical Memorandum No. 4 – Influent and Effluent Management [1] City of Prescott			
	Sundog WRP		Airport WRP	
Year	2004	2005	2004	2005
Annual Average Flow (mgd)	2.762	2.993	0.742	0.837
Annual Dry Weather Average Flow (mgd)	1.990	2.230	0.673	0.727
% Inflow & Infiltration	28%	25%	9%	13%
% Annual Increase in Dry Flows	-	12%	-	8%

Note:

(1) Analysis from Wastewater Collection System Model Study (Carollo, January 2008).

A more detailed analysis was conducted in the collection system study in order to identify specific sections of the collection system that may be contributing major amounts of I/I flows. It was suspected that much of the I/I occurs along sewer mains laid in stream beds. Streams may flow for prolonged periods following precipitation. Based on further evaluation, it was confirmed that I/I continued for approximately 2-3 weeks following major precipitation events. Although a more comprehensive flow monitoring program would be required to develop detailed information regarding the amount of I/I entering each major pipe segment, the flow monitoring and model calibration accomplished in the 2008 System Study provides some insights in that regard. Because flow monitoring for the 2008 System Study was accomplished during a rainy period, the collection system model calibration included some I/I estimates for the flow measurement basins. Table 4.5 summarizes the calibration flows for the flow monitoring basins. This information provides a good starting point for identifying more detailed system rehabilitation priorities relative to reducing I/I within the wastewater collection system.

Table 4.5 Calibration Flows for Flow Monitoring Basins
Technical Memorandum No. 4 – Influent and Effluent Management [1]
City of Prescott

	Estimated Dry Weather Flow	Calibration Day (August 16[2])		Measured Maximum (Aug 9-30)	
	Gallons	Gallons	Percent I/I	Gallons	Percent I/I
Sundog WRP Service Area					
Banning Creek	161,000	169,000	5%	235,000	46%
Copper Basin	234,000	313,000	34%	485,000	107%
Forest Trails	154,000	198,000	29%	240,000	56%
Hassayampa[3]	257,000	257,000	-	-	-
Gurley	167,000	199,000	19%	215,000	29%
Prescott Heights	211,000	237,000	12%	274,000	30%
City Lights	110,000	116,000	5%	151,000	37%
Robinson	177,000	179,000	1%	227,000	28%
Sub-North-South[4]	508,000	758,000	49%	764,000	50%
Prescott Lakes Pkwy	275,000	275,000	0%	325,000	18%
Sundog Sum	**2,254,000**	**3,175,000**	**41%**	**3,865,000**	**71%**
Airport WRP Service Area					
North Force Main	632,000	924,000	46%	1,777,000	181%
Pinion Oaks	85,000	90,000	6%	129,000	52%
Airport Sum	**717,000**	**1,014,000**	**41%**	**1,906,000**	**166%**

Notes:
(1) Analysis from Wastewater Collection System Model Study (Carollo, January 2008).
(2) Calibration day is August 29 for Prescott Lakes Pkwy. Data from multiple days were combined for the Hassayampa Basin.
(3) Blank fields are due to unknown flows in and out of the Hassayampa WRP.
(4) Represents N-S sewer service area that is not covered by other flow monitoring points.

2.3 Flow Equalization at Treatment Facilities

In the previous section, I/I was discussed and evaluated relative to the wastewater collection system, where the primary focus is on locating areas of high I/I and implementing system improvements to reduce or eliminate the I/I. At treatment facilities that receive large volumes of I/I, the main issue is handling the high peak flows associated with the I/I. Because major precipitation events occur in Prescott only a few times each year, it is not cost effective for the City to construct and maintain complete treatment facilities that are sized for the high peak flows associated with I/I events.

One potentially cost effective option for handling peak I/I flows is the use of flow equalization (EQ) basins at the treatment facilities. Flow equalization is the process of controlling flow rate through a wastewater treatment system. The equalization of flow prevents short term, high volumes of incoming flow from forcing solids and organic material out of the treatment process. Flow equalization also controls the flow through each stage of the treatment system, allowing adequate time for the physical, biological and chemical processes to take place. EQ can be installed at the plant influent to avoid over sizing major unit processes (i.e., primary and secondary treatment, tertiary filtration, disinfection), or the EQ facilities can be installed further into the treatment train to address more critical, less robust unit processes (e.g., tertiary filtration and disinfection).

2.3.1 Sundog WWTP Flow Equalization

The City provided detailed flow records for a storm flow event in January 2010. The analysis of the flow records indicated a maximum peak hour factor of 4.8 over the annual average day flow (AADF) of 2.6 mgd. Peak flows over 6.5 mgd were reported for approximately 2.3 days, indicating the strong influence of sustained storm flows on the plant influent flows.

The analysis revealed some uncertainties regarding the duration and magnitude of the storm peak flows during the 2010 event. The maximum limit of the flow meter was 12.5 mgd. Flows of 12.5 mgd were reported for approximately 10 hours in the first part of the storm event. Also, the initial part of the storm peak flow period was not fully captured in the influent flow data records, and therefore it was not possible to determine the full duration of the maximum influent flows.

The analysis of flow records for the January 2010 storm event indicated a need for influent flow equalization and/or collection system improvements to reduce storm peak flows at the plant. The plant influent AADF was 2.6 mgd. Using a design peak hour factor of 2.5 (1989 design criteria), the corresponding peak hour flow is 6.5 mgd. The storm event resulted in peak hour flows of up to 12.5 mgd, which exceeded the peak hour flows expected based on a design peak hour factor of 2.5. Therefore, influent flow equalization and/or collection system improvements are required in order to avoid sizing future treatment facilities to handle storm flows above a design peak hour factor of 2.5 for the Sundog WWTP facilities.

Figure 4.1 shows a summary of the quantitative analysis of the influent flows for the January 2010 storm event. Based on the available data, the recommended equalization volume required is 9 million gallons (MG), which includes a safety factor of 1.2 over the calculated volume required of 7.6 MG. The equalization volume required was calculated based on storing peak flows above a design peak hour factor of 2.5, or a peak hour flow of 6.5 mgd for this particular storm flow event. The required equalization volume was calculated using the difference between the peak hour flow of 6.5 mgd and the hourly flows reported above 6.5 mgd, over the duration of such peak flows. It is important to note that the duration of the storm flows was not fully captured in the available data, and therefore the recommended volume represents the minimum equalization volume required. The safety factor of 1.2 was used to cover the uncertainties in the analysis.

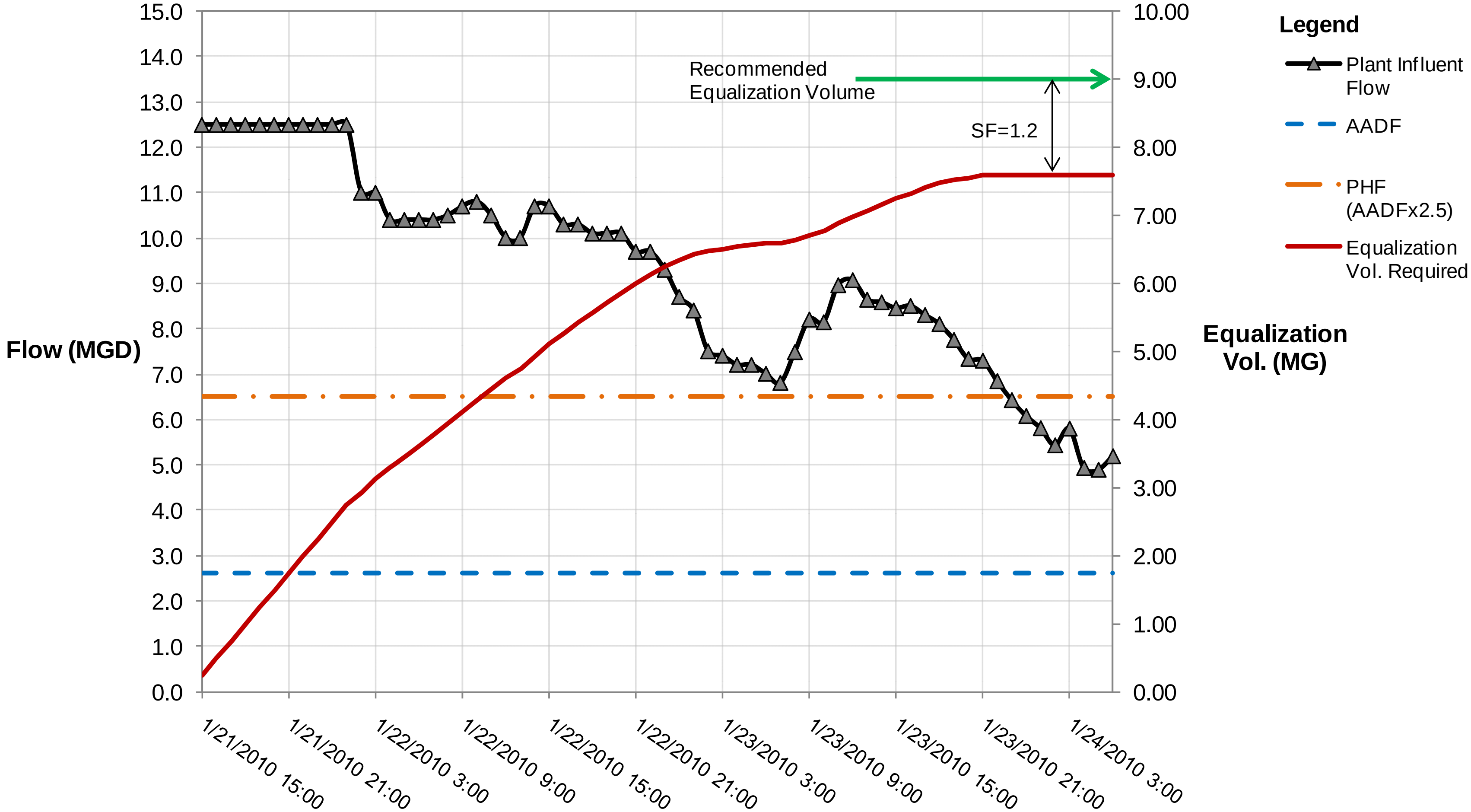
The proposed strategy for handling storm flows at the Sundog WWTP is to plan influent flow equalization facilities for the short and medium term using new tankage for the recommended volume of 9 MG. While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the recommended volume includes a reasonable safety factor over the calculated required volume.

2.3.2 Airport WRF Flow Equalization

The Airport WRF experienced two recent (2008 and 2010) storm events that have prompted the City to further evaluate the need for influent flow equalization at the plant. In order to perform this evaluation, hourly plant influent flow data was provided by the City for detailed analysis.

2.3.2.1 January 2008 Storm Event Analysis

The quantitative analysis of flow records for the January 2008 storm event was inconclusive. The maximum flow in the flow charts used during this flow event was 3 mgd. Analysis of the January 8, 2008 flow chart records indicated that the plant influent flows were higher than 3 mgd for approximately 4 hours. However, it was not possible to determine the magnitude of the influent flows during the 4 hours when the influent flows exceeded 3 mgd due to the range limitation of the flow charts. The annual average day flow (AADF) on January 8, 2008 was 1.04 mgd based on the linear trend of daily flow data between January 2006 and April 2009. Therefore, it was concluded that storm flows resulted in a flow peaking factor larger than 3, but the magnitude of the storm flow peaking factor could not be determined from the flow data available.



In Association with carollo

SUNDOG WWTP FLOW EQUALIZATION ANALYSIS

FIGURE 4.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT

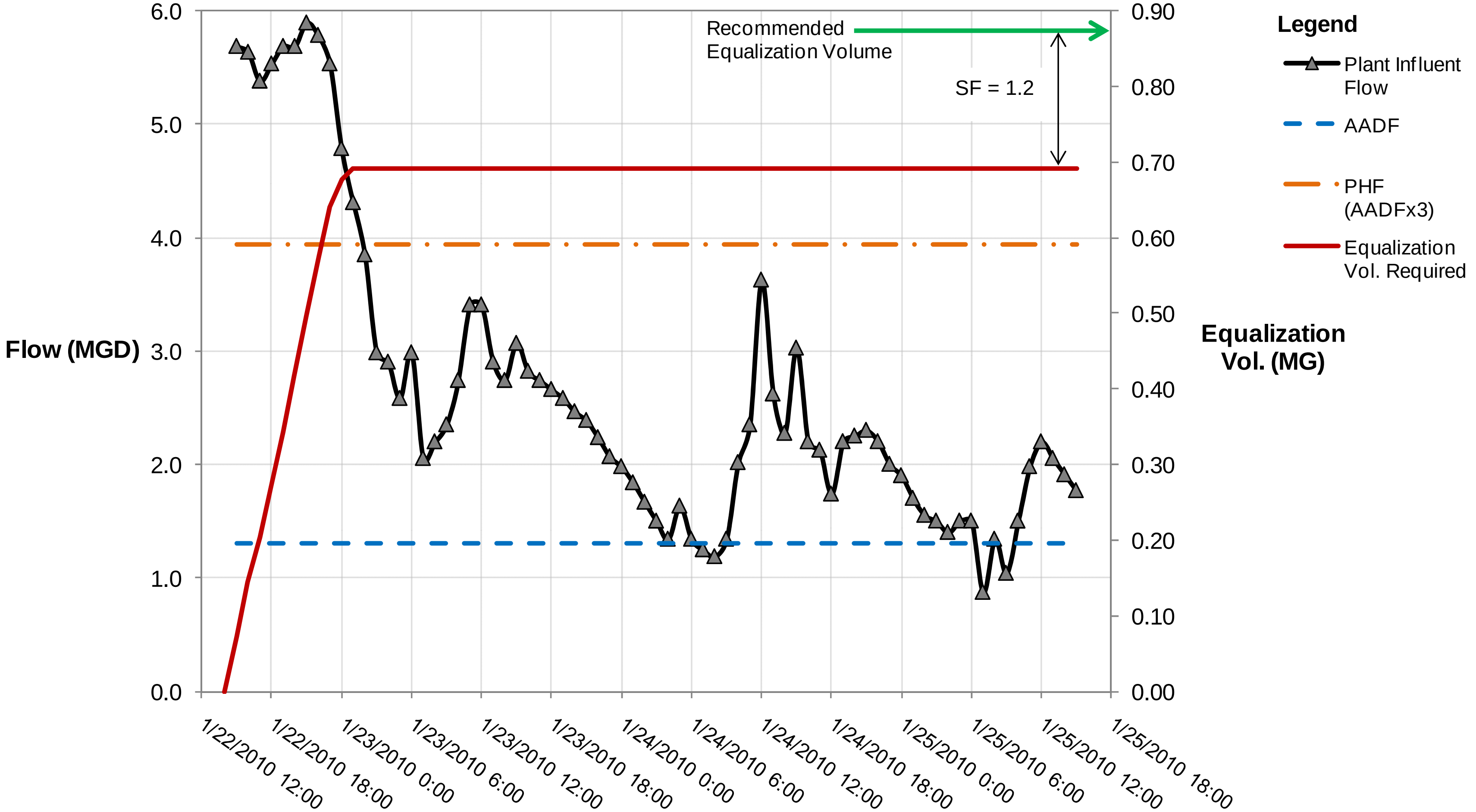
2.3.2.2 January 2010 Storm Event Analysis

The analysis of flow records for the January 2010 storm event indicated a maximum peak hour factor of 4.5 over the AADF of 1.3 mgd. Peak flows averaging approximately 5.7 mgd were reported for approximately 8 hours, eventually dropping below 4 mgd within 3 hours following the period of highest flows.

The analysis revealed some uncertainties regarding the duration of the storm peak flows during the 2010 event. The initial part of the storm peak flow period was not captured in the influent flow data records, and therefore it was not possible to determine the full duration of the maximum influent flows.

The analysis of flow records for the January 2010 storm event indicated a need for influent flow equalization and/or collection system improvements to reduce storm peak flows. The plant influent AADF in January 2010 was 1.3 mgd, based on the linear trend of daily flow data between January 2006 and April 2009. Using a design peak hour factor of 3.0 (1998 design), the corresponding peak hour flow is 3.9 mgd. The storm event resulted in peak hour flows of up to 5.9 mgd, which exceeded the peak hour flows expected based on a design peak hour factor of 3.0. Therefore, influent flow equalization and/or collection system improvements are required in order to avoid sizing future treatment facilities to handle storm flows above a design peak hour factor of 3.0 for the Airport WRF facilities shows a summary of the quantitative analysis of the influent flows for the January 2010 storm event. Based on the available data, the recommended equalization volume required is 0.87 MG, which includes a safety factor of 1.26 over the calculated volume required of 0.7 MG. The equalization volume required was calculated based on storing peak flows above a design peak hour factor of 3.0, or a peak hour flow of 3.9 mgd for this particular storm flow event. The required equalization volume was calculated using the difference between the peak hour flow of 3.9 mgd and the hourly flows reported above 3.9 mgd, over the duration of such peak flows. It is important to note that the full duration of the storm flows was not captured in the available data, and therefore the recommended 0.87 MG represents the minimum equalization volume required. The safety factor of 1.26 was used to cover the uncertainties in the analysis.

The proposed strategy for handling storm flows at the Airport WRF is to plan influent flow equalization facilities for the short and medium term using the existing oxidation ditch basins. Oxidation Ditch No. 1 can hold 0.875 MG, and oxidation ditch no. 2 can hold 0.697 MG, for a combined total of 1.573 MG. This total available volume provides a safety factor of 2.2 over the equalization volume of 0.7 MG estimated based on the 2010 storm event. While there is uncertainty regarding the full duration of the storm flows during the storm event analyzed, the resulting safety factor using the total existing oxidation ditch volume provides a reasonable safety factor over the calculated required volume. Table 4.6 presents a summary of the flow equalization analysis for the Airport WRF.



AIRPORT WRF FLOW EQUALIZATION ANALYSIS

FIGURE 4.2

In Association with carollo

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 4 – INFLUENT AND EFFLUENT MANAGEMENT

Table 4.6	Airport WRF Influent Flow Equalization Analysis Summary Technical Memorandum No. 4 - Influent and Effluent Management City of Prescott, Arizona	
Criteria	**Volume (MG)**	**Safety Factor (1)**
Required Volume		
Calculated Storm Volume (2)	0.697	--
Available Volume (3)		
Oxidation Ditch Basin No. 1	0.875	1.26
Oxidation Ditch Basin No. 2	0.697	1.01
Total Available Volume	**1.572**	**2.27**

Notes:

(1) Safety factor calculated as the ratio between the available basin volumes and the calculated storm volume.

(2) Based on hourly plant influent flow data between January 22 and January 25, 2010.

(3) Based on the assumption that the existing oxidation ditch basins are retrofitted to serve as flow equalization basins.

2.4 I/I Reduction versus Additional Treatment Plant Facilities

As presented in previous sections, implementation of EQ basins for both the Sundog WWTP and Airport WRF is proposed for the short and medium term. Although Prescott's goal is to significantly reduce the amount of I/I entering the collection system, achieving this goal will require a comprehensive, prioritized, multi-year pipe and manhole evaluation and rehabilitation program. The Phase 1 capacity expansion of the Airport WRF is one of the City's highest priorities. As part of a Phase 1 expansion, initial implementation of EQ at the Airport facility would be relatively inexpensive with utilization of the existing oxidation ditch basins.

From the standpoint of operations and potential regulatory impacts on the City, the addition of EQ at both treatment facilities is a higher priority in the short term when compared to major capital investment that focuses on reducing I/I in the collection system. However, I/I is not the only, and likely not the most important driver for collection system rehabilitation. A comprehensive collection system evaluation and rehab program should be based on condition assessment as the primary component for prioritization.

3.0 EFFLUENT MANAGEMENT

The City of Prescott is located within the Prescott Active Management Area (AMA), established under the Arizona Groundwater Code of 1980. The 1980 Groundwater Code, administered by the Arizona Department of Water Resources (ADWR), established a water management strategy that emphasizes conservation, replacement of existing groundwater use with renewable supplies, recharge, and water quality management to help achieve the goal of safe yield by 2025. "Safe Yield" is defined by ADWR as a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn and the annual amount of natural and artificial recharge in the AMA. In support of the safe yield goal and based on the City's "Water Management Policy" (adopted October 2005), the City utilizes 100 percent of the effluent from its two treatment plants, including a portion for reuse (golf course irrigation, commercial, and other) and the remaining amount for groundwater recharge. During 2010 about 67% of the recharge water was from Sundog WWTP and 33% was from Airport WRF. About 72% of the treated effluent was recharged and 28% was used for otherwise.

3.1 Existing Conditions

3.1.1 Recharge

The City of Prescott currently owns and operates a groundwater recharge facility (infiltration beds), which is located adjacent to the City's Airport WRF. The Aquifer Protection Permit designates the discharge limit for the recharge facility at 4.4 mgd (annual average). Effluent from the Sundog WWTP and the Airport WRF, except for the portion of effluent that is reused, is recharged. The City also recharges surface water from Willow and Watson Lakes at this facility.

3.1.2 Reuse

Prescott has contract commitments for up to 2,240 acre-feet per year (2.0 mgd annual average day flow) of effluent to outside customers, including Antelope Hills Golf Course, Hassayampa Village, Prescott Lakes Development, and Yavapai Materials. In addition, the City is obligated to provide up to 1,500 acre-feet per year (1.34 mgd annual average day flow) of effluent credits to the Chino Valley Irrigation District through 2020, and the Yavapai Prescott Indian Tribe has a right to effluent produced on their reservation.

3.2 Water Resources

3.2.1 Proposition 400

The City of Prescott Charter was amended in November 2009 to include the provisions of Proposition 400. The new provisions include requirements for annexations equal to or greater than 250 acres. One of the requirements is that all effluent from these annexations has to be permanently recharged. These requirements will have to be accounted for in future effluent and water resources planning and management.

3.2.2 Water Resources Portfolio

Given the physical/political constraints and the expense of developing new water supplies, and the increasing regulatory and water quality challenges, reclaimed water will continue to be a vital component of the City's water resources portfolio. Future decisions regarding wastewater treatment (including location, quality, etc.) may be even more heavily impacted by the fact that reclaimed water is a water resource, on par with potable water sources.

3.3 Beneficial Use of Effluent

3.3.1 Effluent Management Considerations

As previously noted, the City of Prescott will continue, over the short and long term, to reclaim their treated effluent as a key component of the City's water resources portfolio. Comprehensive planning and management will be required in order to maximize the physical and accounting ("paper water" credits, etc.) utilization of the effluent.

Physical utilization of reclaimed water includes the current practices of recharge and reuse (golf course irrigation and miscellaneous commercial), and may include new opportunities in the future. As effluent volumes increase, recharge facilities will have to be expanded to accommodate the additional amount of reclaimed water, along with surface water that is recharged. Critical issues that may impact recharge expansion include airport restrictions, land availability, and property setback requirements. Less land intensive recharge methods, such as wells, may have to be investigated for expansion of recharge capacity. Long term availability of reclaimed water and overall water resources management will have to be factored in to renewed and new contracts for effluent reuse, along with updated value/price considerations for sale of the water resource to outside entities. Another important factor for irrigation reuse is the significant seasonal variation in demands. This issue must also be considered in negotiating reuse contracts because of the potential impacts and requirements for City infrastructure and management for off-season conditions.

Administrative management of reclaimed water as a critical component of the City's water resources portfolio will likely dictate most, if not all, of the specific types, quantities, and locations of reclaimed water beneficial uses available to the City. Recharge credits are an important part of the overall water resources plan. ADWR and ADEQ requirements and permitting will control many of the decisions regarding reclaimed water. Local requirements, including Proposition 400, will also have direct impact. As previously noted, the Proposition requires that all effluent from future annexations (250 acres and larger) be permanently recharged and not available for recovery, which means that water will be effectively removed from the City's water portfolio.

3.3.2 Effluent Planning

As previously noted, the City's existing recharge facility is permitted for 4.4 mgd (annual average) and the City has contract commitments for approximately 2.0 mgd (annual average) of effluent to outside customers. With existing total effluent flows (Sundog WWTP and Airport WRF) at approximately 3.7 mgd, the City has available capacity to continue reclaiming 100 percent of their effluent in the short term. However, it is important for the City to develop a reclaimed water master plan to accommodate future increased effluent flows. Two major factors that contribute to the need for the reclaimed plan are: 1) The proposed Phase 1 expansion of the Airport WRF to 3.75 mgd will require documentation of compatible effluent management facilities; and 2) The reclaimed water master plan will have to address issues such as annual water balance, given the potential seasonal variations of effluent reuse through outside contracts. Although the City may have contract commitments to provide effluent for irrigation, it may be the City's responsibility to provide "backup" effluent disposal for seasonal and/or wet weather conditions.

The recommended reclaimed water master plan should comprehensively address both physical and administrative aspects of effluent management. It should include immediate and long term water balance computations; identification and evaluation of options for reclaiming effluent; coordination with the City's water portfolio and overall water resource considerations; regulatory and permitting requirements; recommendations for reclaimed water facilities and administrative management documents; and a recommended implementation plan, including schedules and estimated costs.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Infiltration and inflow in the City's collection system and wastewater treatment facilities requires attention. Several issues relative to effluent management from the City's treatment facilities have been identified. Based on the analysis presented herein, the following conclusions and recommendations are presented for the City's consideration.

- Significant levels of I/I have been recently observed at the Sundog WWTP and Airport WRF. Reduction of I/I is necessary in order to avoid constructing and maintaining complete treatment facilities that are sized for the high peak flows associated with I/I events.
- Flow equalization facilities at the treatment plants are recommended for the short and medium term. The proposed strategy for handling storm flows at the Sundog WWTP is to plan influent flow equalization facilities using new tankage. The proposed strategy for the Airport WRF is to plan influent flow equalization facilities using the existing oxidation ditch basins.
- Implementation of a comprehensive pipe and manhole evaluation and rehabilitation program is recommended. This program will allow a detailed identification of critical collection system components contributing to I/I, and a prioritization of specific rehabilitation efforts. Based on the preliminary evaluation presented herein, I/I reduction efforts should begin at the Sundog WWTP service area.
- Development of a reclaimed water master plan to accommodate future increased effluent flows is recommended. This reclaimed water master plan should address short-term and long-term effluent management issues, ranging from the Airport WRF Phase 1 expansion to an investigation of the full range of effluent reclamation and disposal alternatives.

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 5S
Sundog WWTP Alternative
Treatment Technologies

Final

In Association with

Project No. 164890

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City of Prescott

TECHNICAL MEMORANDUM
NO. 5S
SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES

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ES5S TM 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES

ES5S.1 Introduction

The purpose of TM5S is to identify potential treatment technologies for upgrading and expanding the Sundog WWTP, compare those technologies in order to screen the options, and perform detailed analyses of the short listed options to identify the preferred treatment alternative.

ES5S.2 Planning Conditions

Wastewater flow projections for the Sundog WWTP were developed in an effort to estimate the timing of the expansions required at the facility. Flow projections were formed around both aggressive and conservative growth scenarios to develop a range of possible flow increase curves that bracket the required timing for plant capacity expansions. Existing plant capacity was established in TM 3S.

Figure ES5S.1 and Figure ES5S.2 presents the flow increase curves for the City of Prescott Sundog W WTP and the Airport WRF. The aggressive flow increase scenario (Scenario A) is based on actual fast growth period in the City of Prescott, and was developed using historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. The conservative flow increase scenario (Scenario B = 2% annual increase) represents a moderate growth scenario, and is based on growth estimates in the several planning documents for the City of Prescott.

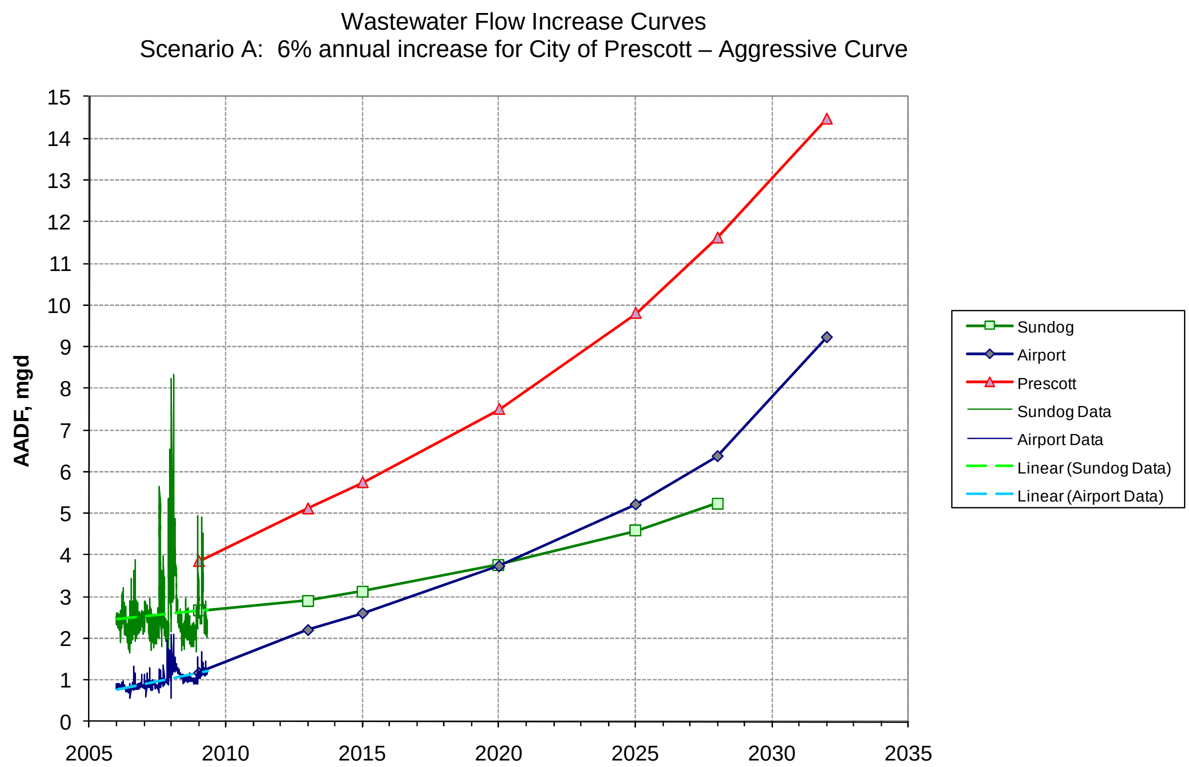


Figure ES5S.1

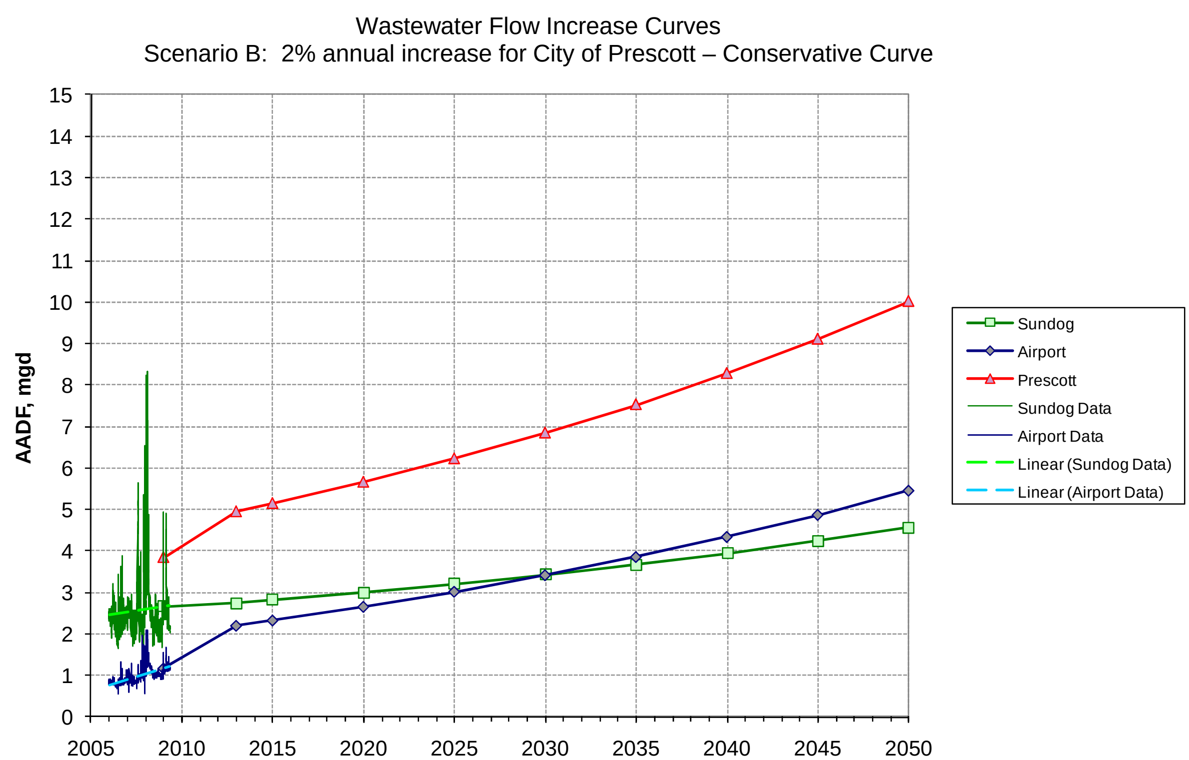


Figure ES5S.2

ES5S.3 Phasing

The build-out annual average day flow (AADF) for the Sundog WRF tributary area is 5.3 mgd based on the City of Prescott Wastewater Master Plan. For the purposes of this technology assessment and site master planning project, the build-out capacity was established at 5.4 mgd.

The capacity for each treatment train of the master planned capacity has been established at three treatment trains of 1.8 mgd. This capacity was established based on discussions with the City in several workshops, and addresses the City's need for additional treatment capacity beyond the existing plant capacity of 3.0 mgd. The first phase capacity of 3.6 mgd is more cost-effective than a four treatment train alternative and also provides a reasonable timeframe before the next capacity expansion is required.

Figure ES5S.3 shows the expected timing associated with the existing capacity, and with a first phase of improvements to achieve a treatment capacity of 3.6 mgd. It is estimated that the plant will reach its existing capacity between the years 2014 and 2020. It is also estimated that with a Phase 1 capacity of 3.6 mgd, the Sundog WWTP would require the next expansion phase to be in service as early as the year 2019 and as late as the year 2034.

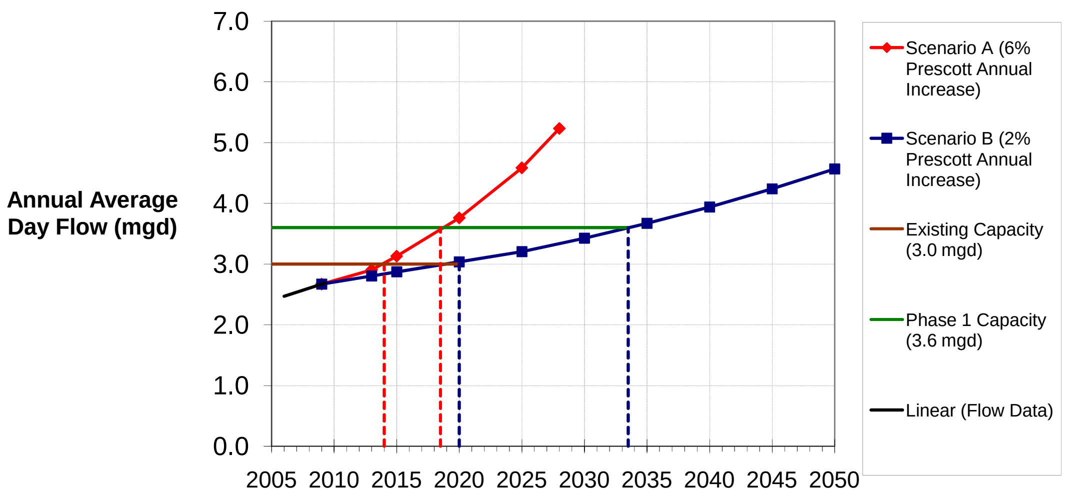


Figure ES5S.3

ES5S.4 Alternatives Analysis/Selection

For the initial evaluation of process alternatives, a full range of twelve treatment options were considered for completeness. While existing process technologies at the plant was not a requirement of the master plan, there are significant advantages to the City with maintaining a familiar process. The full range of treatment alternatives were reviewed and discussed in project workshops with the City. There was a project team consensus that two alternatives should be brought forward for detailed evaluation at both plants:

- Alternative 1 – conventional activated sludge with Modified Ludzack-Ettinger Process (MLE) for biological nitrification and denitrification
- Alternative 2 – Membrane Bioreactor (MBR) with MLE for biological nitrification and denitrification

Detailed analyses of the required components and sizes for each technology were performed in order to develop costs for both capital improvements and O&M. The resulting cost comparison is summarized in Table ES5S.1 below.

Table ES5S.1 Alternatives Detailed Cost Comparison (Ultimate)
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Cost Type	Alternative 1 MLE	Alternative 2 MBR
Total Probable Construction Cost	$ 75,131,000	$ 74,963,000
Total Probable Present Worth O&M Cost	$ 35,614,000	$ 44,889,000
Total Probable Present Worth Cost	$ 110,745,000	$ 119,852,000

Additionally, a non-economic comparison of alternatives was performed to finalize the process selection. Table ES5S.2 summarizes the results of the non-economic evaluation.

Table ES5S.2 Non-Economic Factor Comparison
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

	Weighting Factor	Alternative 1 – Conventional MLE		Alternative 2 - MBR	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
I&C Intensity	x 3	8	24	4	12
Compatibility w/AOP's	x 2	5	10	8	16
Sustainability Reuse	x 3	6	18	8	24
TOTAL			156		150

Note:
1. Comparison of non-economic factors where 10 = best and 1 = worst

The costs and non-economic factors associated with MLE versus MBR treatment alternatives were presented and reviewed with City staff during project workshops. Based on the evaluation results and detailed discussions among project team members, MLE is the preferred treatment alternative for future expansions and improvements at the Sundog WWTP. Primary reasons for this recommendation include the following:

- MLE has a comparable capital cost and lower energy and O&M costs compared with MBR.
- MLE is consistent with the current treatment technology and is less complex than MBR.
- There is currently no water quality requirement for MBR treatment and MLE treatment does not preclude future advanced treatment facilities for emerging contaminants.
- MLE retains the ability to meet MBR effluent quality with the addition of advanced filtration facilities.

Technical Memorandum No. 5S

1.0 INTRODUCTION

This Technical Memorandum (TM) is part of the Sundog WWTP and Airport WRF Technology and Capacity Master Plan for the City of Prescott. The purpose of this TM is to identify potential treatment technologies for upgrading and expanding the Sundog WWTP, compare these technologies to produce a short list of options, and perform detailed analysis of the short listed options to identify the preferred treatment alternative for upgrading and expanding the plant.

2.0 PLANNING CONDITIONS

2.1 WASTEWATER FLOW INCREASE

Wastewater flow projections for the Sundog WWTP and Airport WRF were developed in an effort to estimate the timing of the expansions required at both facilities. The approach to develop the flow projections was to establish aggressive and conservative flow increase scenarios in order to develop a range of possible flow increase curves that provide a basis for determining the required capacities at each treatment facility. Existing capacity of the Sundog WWTP was established in TM 3S - Sundog WWTP Existing Conditions.

2.1.1 Scenario A – Aggressive Flow Increase

An aggressive flow increase scenario (Scenario A) was based on the historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. This scenario captures an actual fast growth period in the City of Prescott, and is considered representative of a possible aggressive flow increase scenario for the City's treatment facilities.

Influent flows to both facilities were added in order to determine the total wastewater flow increase in the City of Prescott. The annual percent wastewater flow increase for the City of Prescott based on influent flow data was calculated to be 6.1 percent for the period between January 2006 and April 2009.

Due to the different nature of the service areas for the Sundog WWTP and the Airport WRF, the percentage of the total flow increase will be different for each plant. The Sundog WWTP service area is significantly more developed than the Airport WRF service area. Therefore, the rate of flow increase at the Sundog WWTP is expected to be slower than the rate of flow increase at the Airport WRF.

In order to develop the flow increase curves for each plant, it was assumed that 64 percent of the flow increase for the City is sent to the Airport WRF, and 36 percent is sent to the Sundog WWTP. Two reference points were used to determine the relative split of the City's flow increase to each of the two treatment facilities.

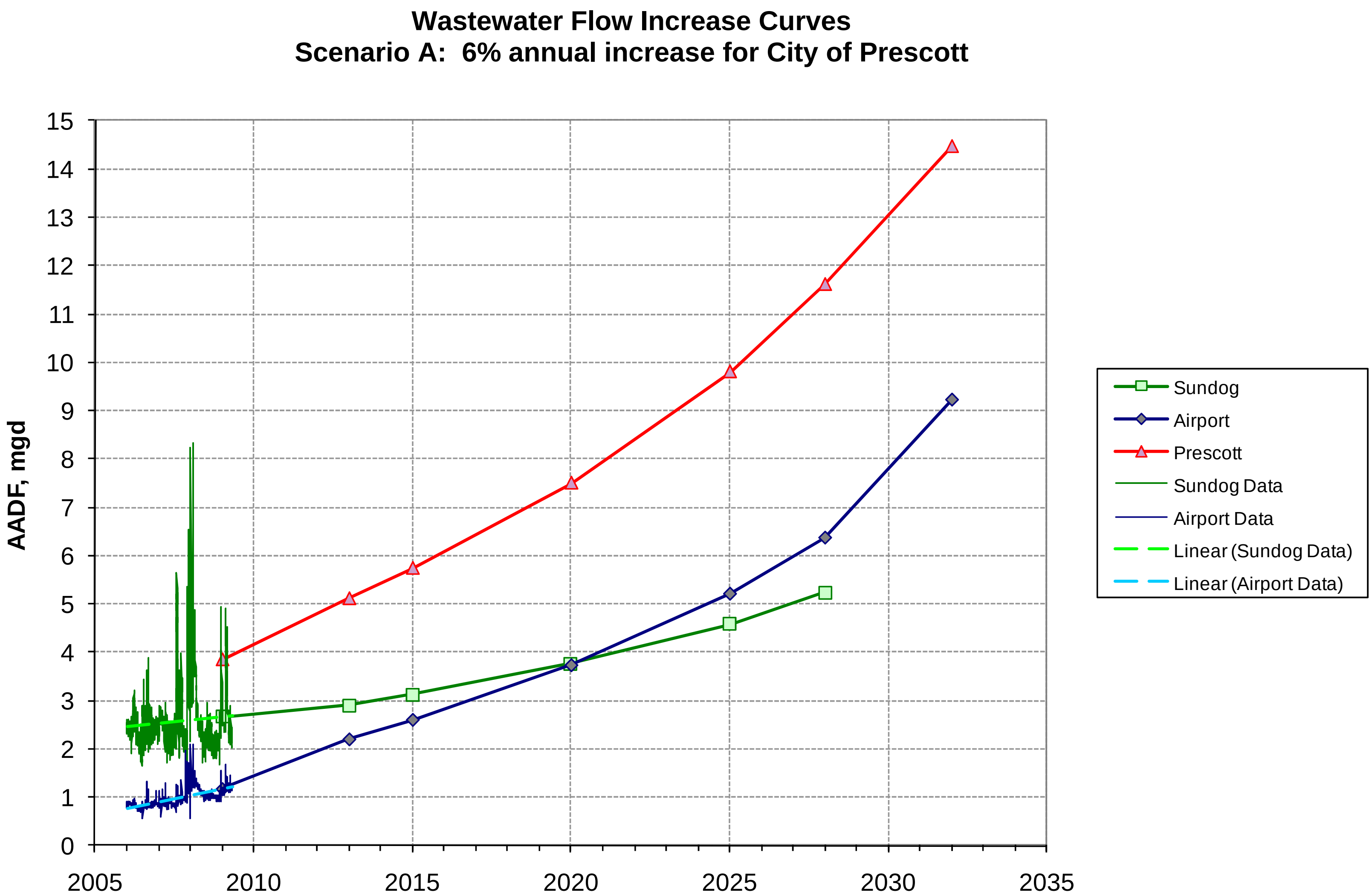
- Based on historical flow data between January 2006 and April 2009, 67 percent of the flow increase for the City occurred at the Airport WRF, and 33 percent occurred at the Sundog WWTP.
- Buildout flows for the Airport WRF and the Sundog WWTP are 9.6 mgd and 5.4 mgd, respectively. At buildout, 64 percent of the wastewater flow is treated at the Airport WRF and 36 percent of the flow is treated at the Sundog WWTP.

Table 5S.1 summarizes the historical flow data used to develop assumptions presented in this aggressive flow increase scenario. Figure 5S.1 presents the flow increase curves for the City of Prescott, the Sundog WWTP, and the Airport WRF.

Table 5S.1 Historical Flow Increase at City of Prescott Treatment Facilities
Technical Memorandum No. 5S - Alternatives Evaluation
City of Prescott, Arizona

Criteria	Airport WRF	Sundog WWTP	Total
Influent Flow January 2006, mgd	0.772 (1)	2.470 (1)	3.242
Influent Flow April 2009, mgd	1.215 (1)	2.691 (1)	3.906
Annual Flow Increase, %	17.2	2.7	**6.1**
Flow increase 2006-2009, mgd	0.443	0.221	0.664
Fraction of Flow Increase	0.67	0.33	1.00

Notes:
1. Based on linear trend of daily average flow data.
2. Sundog influent flows include discharge flows from the Hassayampa Water Reclamation Plant (WRP) to the collection system. Annual average flows from the Hassayampa WRP are approximately 12,000 gallons per day of waste activated sludge from the activated sludge process (8,000 gpd between November-April, and 16,000 gpd between April-November).



FLOW INCREASE CURVES - SCENARIO A (AGGRESSIVE)

FIGURE 5S.1

In Association with carollo

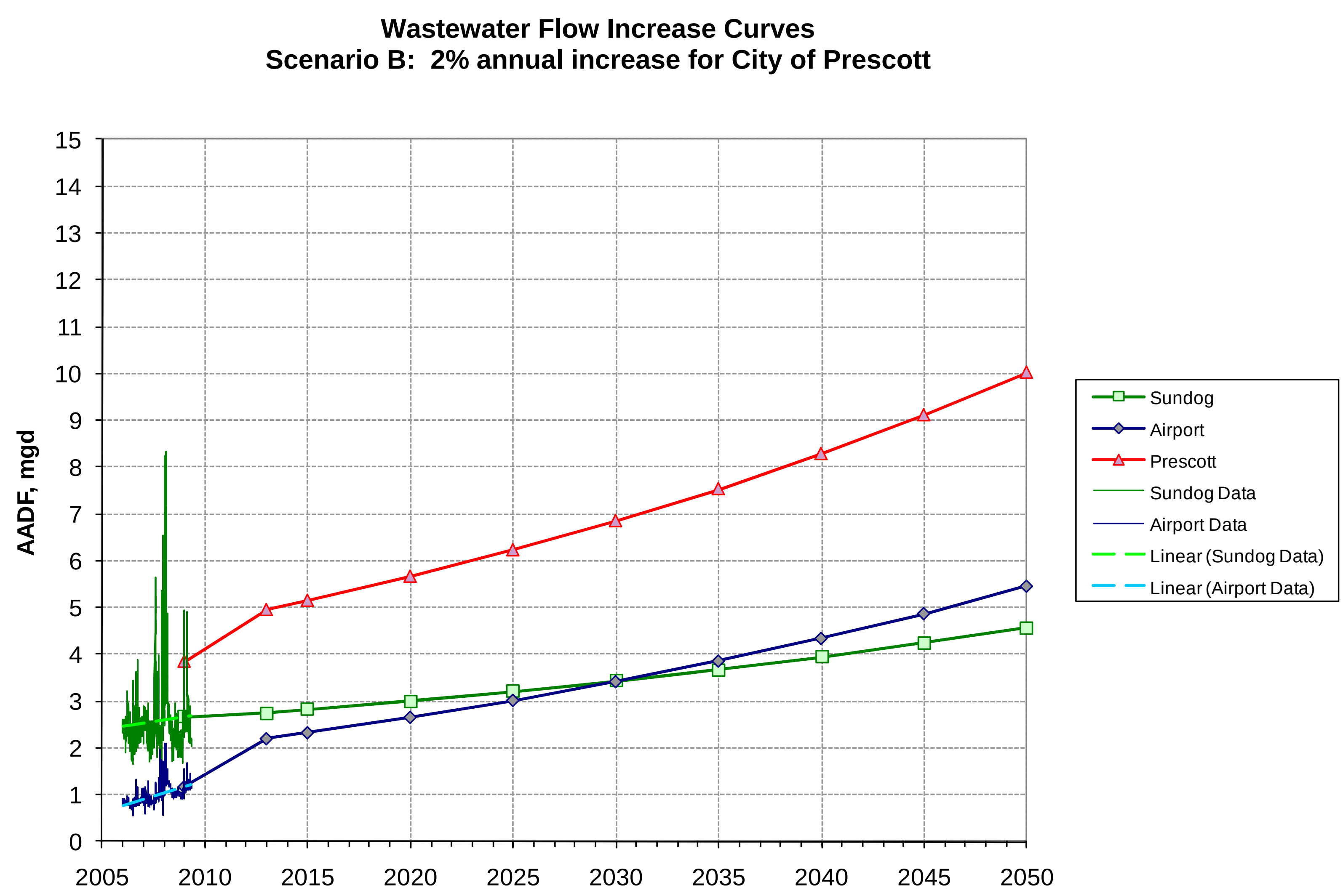
CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

2.1.2 Scenario B – Conservative Flow Increase

A conservative flow increase scenario (Scenario B) represents a moderate growth scenario. An annual flow increase of 2 percent was assumed to develop conservative wastewater flow increase curves for the Airport WRF and Sundog WWTP. The assumption is based on growth estimates used in the following planning documents for the City of Prescott:

- 2003 Prescott General Plan. Ratified May 18, 2004
- Yavapai County General Plan, April 2003
- Arizona Subcounty Population Projections. Arizona Department of Economic Security, Research Administration, Population Statistics Unit, 12/01/06
- Wastewater Collection System Model Study, 2008.

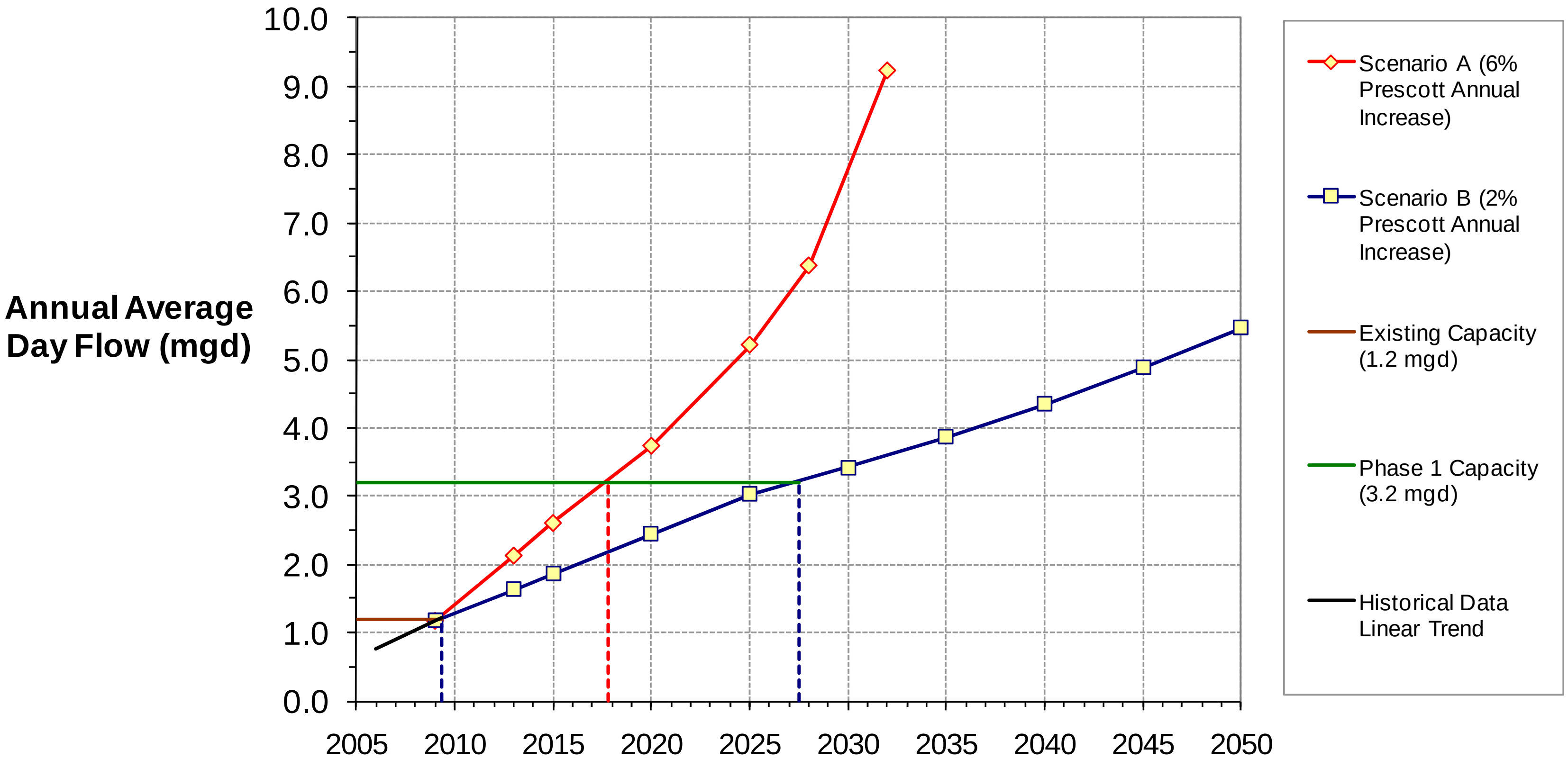
In order to develop the flow increase curves for each plant, it was assumed that 64 percent of the flow increase for the City is sent to the Airport WRF, and 36 percent is sent to the Sundog WWTP. Figure 5S.2 presents the flow increase curves for the Sundog WWTP, and the Airport WRF.



FLOW INCREASE CURVES - SCENARIO B (CONSERVATIVE)

FIGURE 5S.2

In Association with carollo



FLOW INCREASE CURVES – AIRPORT WRF

FIGURE 5S.3

In Association with carollo

CITY OF PRESCOTT

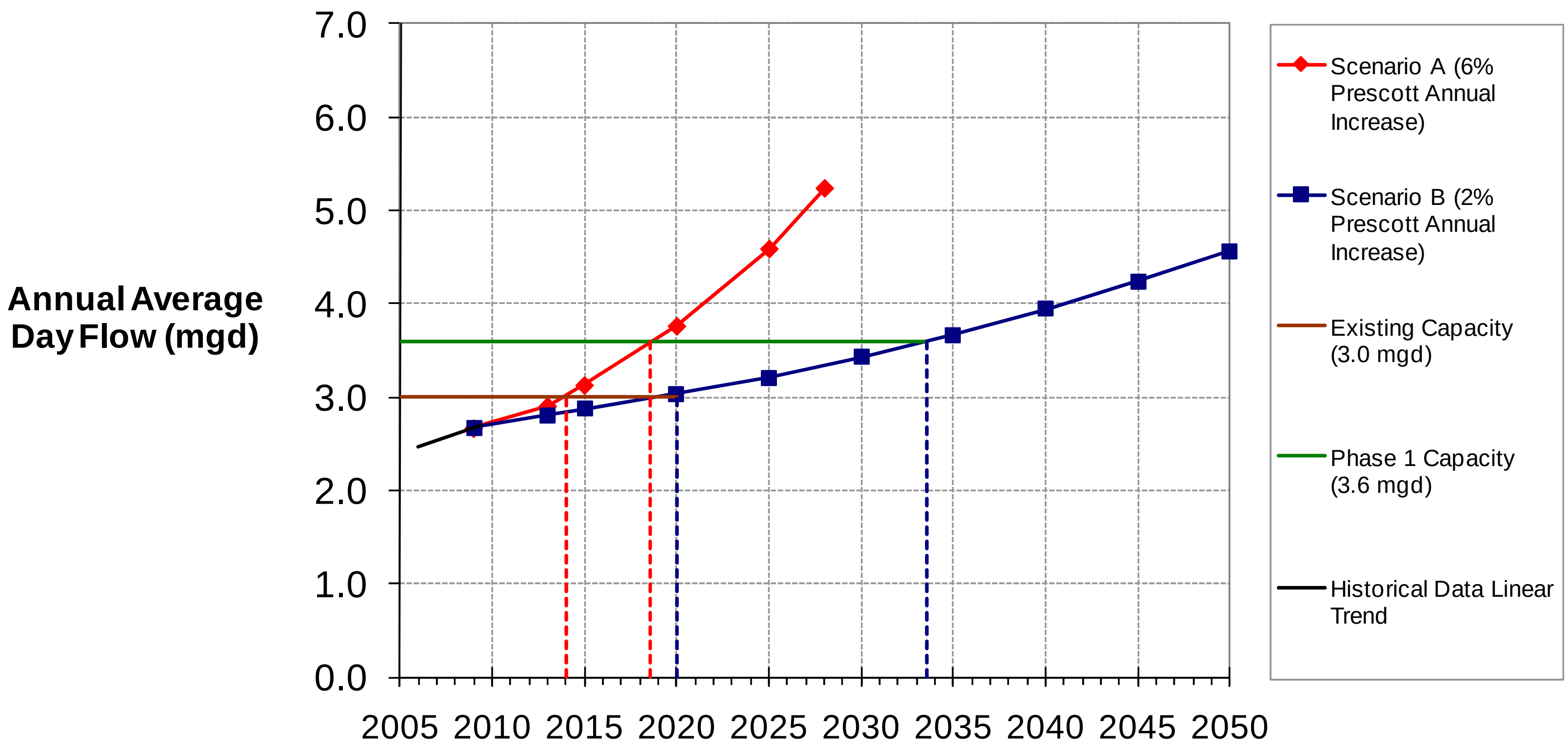
TECHNICAL MEMORANDUM NO. 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

2.1.3 Sundog WWTP Phasing

The buildout annual average day flow (AADF) for the Airport WRF tributary area is 5.4 mgd.

The capacity for each treatment train of the master planned capacity was established at 1.8 mgd (three treatment trains total). This approach to phased capacity was established based on discussions with the City in several workshops. Improvements to the existing two trains will provide the current needed capacity expansion (3.6 mgd) compared to the existing capacity of 3.0 mgd. This phasing approach is more cost-effective than a four treatment train alternative and the first phase of construction (3.6 mgd) also provides a reasonable timeframe before the next capacity expansion is required.

Based on the flow increase scenarios presented in Sections 2.1.1 and 2.1.2 above, Figure 5S.4 shows the expected timing associated with the existing capacity and the first phase of 3.6 mgd improvements. It is estimated that the plant will reach its existing capacity between the years 2014 and 2020. It is also estimated that with a Phase 1 capacity of 3.6 mgd, the Sundog WWTP would require the ultimate expansion phase to be in service as early as the year 2019 and as late as the year 2034.



FLOW INCREASE CURVES – SUNDOG WRF

FIGURE 5S.4

3.0 ALTERNATIVE TREATMENT TECHNOLOGIES

For the initial evaluation of process alternatives, a full range of treatment options were considered. These process technologies are discussed relative to their potential application to both the Sundog WWTP and the Airport WRF. While common process technologies at each plant was not a requirement of the master plan, there are significant advantages to the City with common processes. The full range of treatment alternatives were reviewed and discussed in project workshops with the City.

The following subsections present the full range of treatment technologies considered, associated benefits and challenges, and indentifies the preferred alternatives for detailed consideration.

3.1 Conventional Activated Sludge (MLE)

The Modified Ludzack-Ettinger (MLE) process has an anoxic zone at the head of the aeration basin that receives influent wastewater, return activated sludge, and recycled mixed liquor suspended solids (MLSS) from the end of the aerobic zone. Nitrates produced in the aerobic zone are denitrified in the anoxic zone. The anoxic zone is followed by an aeration zone enabling nitrification and elimination of organic pollutants. Additionally, MLE allows for swing zones that assist with maintaining nitrogen limits as wastewater characteristics vary seasonally. Activated sludge solids are separated in final clarifiers.

Advantages

- Consistent with existing plant technology.
- Proven technology.
- Simple operation.
- Lower energy than MBR.

Disadvantages

- Requires larger footprint than MBR.
- Requires tertiary filtration to meet Class A+ (compared to MBR).
- Increased disinfection requirements compared to MBR.

Summary

The conventional activated sludge (MLE) process is recommended for detailed evaluation. This process provides proven, reliable nitrogen removal with a stable activated sludge process.

3.2 Four-stage Biological Nutrient Removal (BNR)

The four-stage BNR process comprises an MLE process (anoxic/aerobic zones described above) followed by a post-anoxic and reaeration zone for further removal of nitrates (typically using an external carbon source), and re-aeration to strip any nitrogen gas and aerate the MLSS prior to settling. Activated sludge solids are separated in final clarifiers.

Advantages

- Potential to achieve lower effluent total inorganic nitrogen (TIN).

Disadvantages

- Additional post-anoxic and reaeration/oxic step.
- Additional nitrogen removal is not needed to meet Class A+ TN limit of 10 mg/L.
- Slightly higher cost than MLE due to additional baffle walls, mixers, and aeration.

Summary

The four-stage BNR process **is not** recommended for detailed evaluation. There is no requirement to achieve additional nitrogen removal beyond the capabilities of an MLE process.

3.3 Extended Aeration Oxidation Ditch

The extended aeration oxidation ditch process typically occurs in a race-track tank that is both mixed and aerated using mechanical rotors. The racetrack provides volume for both aerobic and anoxic conditions to exist, although these are not defined in separate zones or tanks. Therefore some ditches include external upstream tankage for controlled denitrification in anoxic tanks. Activated sludge solids are separated in final clarifiers.

Advantages

- Simple operation.
- Stable operation.
- Facility does not require blower complex for aeration.

Disadvantages

- Long hydraulic retention time (typically greater than 20 hours) requires relatively large footprint.
- Relatively high capital cost for tankage.
- Relatively higher operating cost for mechanical aeration and since rotors provide both mixing and aeration, may limit operations flexibility.
- Requires external anoxic basin for MLE process, or relies on simultaneous nitrification and denitrification for nitrate removal.

Summary

The extended aeration oxidation ditch process **is not** recommended for detailed evaluation. It is anticipated that it would be more costly to construct and operate than conventional MLE activated sludge and enhanced stabilization is not required with anaerobic digestion.

3.4 Step Feed Biological Nitrogen Removal

The step feed process is typically constructed in a four-pass aeration basin with influent equally distributed during dry weather to an anoxic zone and following aeration zone in each of the 4 passes. During wet weather flows, the final pass of the aeration tank receives significantly more influent to provide a solids-contact treatment prior to settling and discharge. The process typically produces effluent with higher ammonia concentration than the MLE process due to the short retention time of the final pass for treating 25 percent of influent flows. Activated sludge solids are separated in final clarifiers.

Advantages

- Smaller aeration basin volume relative to conventional plug flow MLE system.
- No requirement for internal recycle pump.
- Helps to manage wet weather flows.

Disadvantages

- Higher rate process therefore may occasionally struggle to meet total nitrogen alert level of 8 mg/L
- Typically subject to significant surface foam formation.
- Comparable costs to MLE.

Summary

The step feed BNR process **is not** recommended for detailed evaluation. The process is more difficult to control and operate than conventional MLE activated sludge and typically bleeds ammonia in the final effluent due to the step feed process, which could represent a long-term permit issue (future ammonia limit).

3.5 Separate Carbonaceous and Nitrifying Activated Sludge Systems

The two-stage process is typically constructed as a high-rate carbonaceous treatment activated sludge system tankage with clarifiers followed by a separate nitrifying activated sludge system tankage with anoxic zones using carbon addition for denitrification and final clarifiers for activated sludge solids separation.

Advantages

- Isolates carbonaceous removal, nitrifying and denitrifying steps to optimize each step independently.

Disadvantages

- Requires a greater number of clarifiers therefore more expensive than MLE.
- Denitrification is typically accomplished with additional of an external carbon source further increasing the complexity and operating costs for this option.

Summary

The two-stage process **is not** recommended for detailed evaluation. The process is more costly to construct and operate than conventional MLE activated sludge and does not utilize available influent carbon for denitrification.

3.6 Membrane Bioreactor in MLE Configuration

The membrane bioreactor (MBR) process in MLE configuration operates very similar to a conventional MLE process, with the key difference that the final clarification step in the conventional MLE process is replaced with membrane filtration. Membrane filtration allows the system to operate at much higher mixed liquor suspended solids concentrations compared to a conventional process, and therefore reduce the required volume of the aeration basins.

The MLE process has an anoxic zone at the head of the aeration basin that receives plant influent and recycled MLSS from the end of the aerobic zone or from the membrane basins. Return activated sludge from the membrane basins may be directed to the aerobic zone to reduce the impact of DO on the anoxic zone. Nitrates produced in the aerobic zone are denitrified in the anoxic zone. The anoxic zone is followed by an aeration zone enabling nitrification and elimination of organic pollutants. Final effluent is filtered from the MLSS using proprietary polymeric membranes producing a filtered final effluent.

Advantages

- Small footprint.
- Stable operation.
- Performance not dependent on sludge settling characteristics.
- Very good effluent quality due to use of microfiltration.
- Does not require final clarifiers or tertiary filters.
- Allows for some forms of future advanced treatment systems for emerging contaminants.

Disadvantages

- Relatively high operating cost.
- Filtration system is sized based on hydraulic capacity of the membrane system. Therefore for peak wet weather flows equalization is required.

- Membrane replacement is a significant expense that must be annually budgeted and accounted for.
- Instrumentation and control equipment is intensive.
- Without sufficient equalization storage, the plant is susceptible to overflowing in the event of solids overload and plugging of the membrane filtration system.

Summary
The MBR process is recommended for detailed evaluation. The process provides reliable nitrogen removal with stable activated sludge process, and enhances effluent quality with membrane filtration.

3.7 Sequencing Batch Reactors

Sequencing batch reactors (SBR) employ conventional activated sludge processes that operate in "slices of time" in a common tank, rather than in multiple tanks in continuous time. In the continuous inflow variant, influent wastewater flows into the basin continuously regardless of sequence in the cycle. In the true batch system influent is not continuous. Treatment takes place in three steps:

Step 1: anoxic period when MLSS is mixed with incoming influent for denitrification of nitrates.

Step 2: aeration period during which air is blown into the basin through a diffusion system.

Step 3: the aerated MLSS settles leaving a clear supernatant on top of the settled sludge.

Step 4: The supernatant is decanted to the effluent line.

The normal cycle time is approximately 4.8 hours with 0.8 hours anoxic, 2 hours of aeration, 1 hour of settlement, and 1 hour of decanting. SBR plants generally include a storm cycle which is shorter than the normal treatment cycle.

Advantages
- Does not require separate clarifiers
- Smaller footprint than conventional activated sludge

Disadvantages
- Requires influent or effluent equalization ponds based on non-continuous operation.
- Plant operation is totally dependent on PLC operation
- Technology traditionally limited to small plant capacities (<1 mgd).
- Higher capital cost than MLE as existing oxidation ditch cannot be used for aeration.

Summary

The SBR process **is not** recommended for detailed evaluation. In this process, it is more difficult to control unwanted nuisance foaming and bulking organisms compared to a conventional MLE activated sludge process, and therefore the SBR process may lead to more effluent total suspended solids excursions particularly during high flows.

3.8 Phased Oxidation Ditch System "BioDenitro™"

The BIO-DENITRO™ process comprises two identical activated sludge tanks and a settling tank. The activated sludge tanks, fitted with aeration and agitation devices, are interconnected and operate either as aerobic or anoxic tanks. Treatment is achieved by switching feed and discharge between the two tanks, in two phases, A and B:

- Phase A, the untreated water is introduced into the first tank operating as an anoxic tank, from where the nitrates accumulated during the previous phase are removed. The mixed liquor passes into the second tank which operates under aerobic conditions to enable nitrification and elimination of organic pollutants.
- Phase B, the water is admitted to the second tank, and the denitrification and nitrification phases are inverted compared to phase A.

Advantages

- Simple operation.
- Stable operation.
- Numerous facilities worldwide employ this technology.

Disadvantages

- Large footprint for secondary treatment
- Difficult to plan for redundant operation
- Higher capital cost than MLE

Summary

The phased oxidation ditch process **is not** recommended for detailed evaluation. This process would be more costly to construct and operate than conventional MLE activated sludge and is expensive to include redundant capacity.

3.9 Trickling Filters/Biotowers

Primary effluent is pumped to a trickling filter or biotower and distributed over the media using a hydraulic or mechanical distributor. The wastewater is oxidized by bacteria that grow attached to the fixed media. Most units include a recycle system to maintain a minimum wetting rate for the media. Some systems include a downstream short residence time activated sludge system for coagulation of biological solids. The solids are settled in final clarifiers before discharge. The denitirification process also occurs on fixed media and typically uses supplemental carbon for denitrification.

Advantages

- Low operating cost.
- Attached-growth processes are less susceptible to solids washout.
- Low solids loading to secondary clarifiers.

Disadvantages

- Not suitable for biological nitrogen removal (unreliable for complete nitrification without biofilm using alkaline solutions).
- Downstream denitrification requires supplemental carbon addition.
- Higher capital cost than MLE as existing oxidation ditches cannot be used for aeration.

Summary

Trickling filters or biotowers **are not** recommended for detailed evaluation. The process is estimated to be more costly to construct than conventional MLE activated sludge, and depending on the biofilm and snail control requirements may be more expensive to operate.

3.10 Moving Bed Bioreactors (MBBR) and Denitrification Filters

Additional treatment could be provided downstream of the existing activated sludge process. A moving bed biological reactor (MBBR) could be installed after the secondary clarifiers to completely nitrify residual ammonia followed by subsequent denitrification and suspended solids removal in a denitrification filter. The MBBR process is designed to provide a surface on which to grow biomass for nitrification without loading the mass on the clarifier as is done in conventional activated sludge processes. The media is free-floating in a basin. Diffused aeration provides both the oxygen requirement for nitrification and the mixing requirement to keep media well mixed.

Advantages

- Small footprint technology.
- Attached growth process not susceptible to solids washout.

Disadvantages

- Storage and management of floating media, particularly during basin inspection and repair is problematic.
- Basins require screens to keep media within the tank, the screens require excellent influent screening
- MBBR facilities utilize proprietary media.

- Downstream denitrification requires supplemental carbon addition.
- Higher capital cost than MLE as existing oxidation ditch cannot be used for aeration.

Summary

The MBBR process **is not** recommended for detailed evaluation. The process is estimated to be more costly to operate than conventional MLE activated sludge due to the need for carbon addition for denitrification.

3.11 Integrated Fixed Film/Activated Sludge Process (IFAS)

Additional treatment could be provided within the existing activated sludge process by installing floating media within dedicated zones of the installed tankage . An IFAS system will assist in completely nitrifying residual ammonia in smaller tankage and denitrification can then be accomplished in larger zones within the existing aeration basins.
The IFAS process is designed to provide a surface on which to grow biomass for nitrification in conjunction with suspended growth biomass. The media is free-floating in a basin. Diffused aeration provides both the oxygen requirement for nitrification and the mixing requirement to keep media well mixed.

Advantages

- Small footprint technology
- Lower solids loading to secondary clarifiers.
- Use of fixed-film biomass reduces chances of loss of biological treatment due to storm flow washout or process upset.

Disadvantages

- Storage and management of floating media, particularly during basin inspection and repair is problematic.
- Basins require screens to keep media within the tank, and the screens require excellent influent screening.
- IFAS facilities utilize proprietary media.
- Additional aeration requirements are needed to properly maintain the free-floating media in suspension

Summary

The IFAS process **is not** recommended for detailed evaluation. It is more difficult to maintain than conventional MLE activated sludge due to the need for media, screens, as well as additional aeration and influent screening requirements.

3.12 Biological Aerated Filters – Nitrification and Denitrification

Multiple vendor market versions of biological aerated and denitrifying filters (BAFs) are used for wastewater treatment. BAFs are used for both BOD and TSS removal, as well as for nitrification and denitrification. The technology is proven at both small scale and large scale. Two companies (Kruger, owned by Veolia Water, and Infilco Degremont, owned by Suez) have supplied the majority of systems currently operating. Kruger supplies the BioStyr^{TM} process. Infilco Degremont supplies the BioFor^{TM} process.

BAFs could be used to nitrify the waste stream from the primary clarifiers. The nitrifying BAF effluent could then be denitrified in a denitrifying BAF. Influent flow is pumped to a common channel where flow is hydraulically split to the operating nitrifying BAF. BAFs are individually controlled through automatic gates and valves. The BAF backwash process including air scour is fully automated. The backwash is directed to the primary clarifiers for co-settling with primary solids. No separate backwash tank is required.

Advantages

- Applicable for tertiary nitrification
- Less proven than denitrification filters for producing low effluent TSS.

Disadvantages

- Potential for clogging with large debris
- Subject to surfactant foaming
- Proprietary vendor system
- Higher capital cost than MLE as existing oxidation ditch cannot be used for aeration.

Summary

Biological aerated filters **<u>are not</u>** recommended for detailed evaluation. These filters are estimated to be more costly to construct and operate than conventional MLE activated sludge.

3.13 Filtration and Disinfection

Based on the evaluation and recommendations presented in TM7-Tertiary Filtration Evaluation, conventional tertiary filtration is based on converting the existing Sundog WWTP travelling bridge filter structures to disc filter technology.

For disinfection, evaluation of overall treatment train alternatives under this TM is based on UV disinfection for consistency with the existing plant technology. However, when the plant is expanded, it is recommended that alternative methods of disinfection be evaluated during the preliminary design phase. As a conservative measure, costs for UV disinfection have been used to estimate the future construction dollars required. Disinfection requirements in this TM are based on meeting Class A+ requirements at the Sundog WWTP rather than the current Class B+ design.

4.0 DESIGN FLOWS AND LOADS

Wastewater flow peaking factors were developed in Technical Memorandum No. 3S, and are based on historical wastewater flow data between 2006 and 2009 for the Sundog WWTP. Table 5S.2 presents the design wastewater parameters used for the evaluation of treatment alternatives in this Technical Memorandum No. 5S.

Table 5S.2 Design Wastewater Flows and Peaking Factors
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Flow Criteria	Hydraulic Peaking Factor [(1)]	Phase 1 Flow (mgd)	Buildout Flow (mgd)
Annual Average Day Flow	1.0	3.6	5.4
Maximum Month Average Day	2.0	7.2	10.8
Peak Day	3.3	11.9	17.8
Peak Hour	4.5	16.2	24.3

Note:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

As described in TM3S, the maximum month flows and maximum month influent concentrations are not coincident. Therefore, as indicated in TM3S, the design loads presented in Table 5S.3 are calculated for the condition of max month flow at average concentration for winter WW temperature and average flow at max month concentration for summer WW temperature.

Table 5S.3 Influent Concentration and Loads @ Build-Out Capacity
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameters	Average (mg/L)	92%ile Max Month (mg/L)	Summer Max Month Load (ppd)	Winter Max Month Load (ppd)
BOD_5	390	608	27,382	35,128
TSS	418	676	30,444	37,650
TKN	39.5	57	2,567	3,558
NH3-N	31.5	48.8	2,198	2,837
pH	7.7	7.7	7.7	NA
Temperature	19.6	23	20	12.4

5.0 COMMON SYSTEMS FOR EITHER TECHNOLOGY

5.1 Screening and Grit Removal

Both treatment alternatives would include raw wastewater screening and grit removal. The conventional MLE system will require conventional ½ inch screening but the MBR system requires 2 mm fine screens to prevent damage to membrane fibers. For both systems vortex grit removal technology is assumed for removal of larger silts and sand.

5.2 Flow Equalization

Peak storm flow impacts at the Sundog WWTP are significant based on recent storm event data. An analysis of on-site flow equalization versus sewer rehabilitation was addressed in TM 4. Based on the recommendations presented in TM 4, 9 million gallons of primary effluent flow equalization is recommended for Phase 1 of the Sundog WWTP. Details of the proposed flow equalization facility are presented in Tables 5S.4 and 5S.5.

5.3 Sludge Generation/Treatment

Solids treatment and processing needs to be included to provide a thorough comparison of treatment plant technologies. For the Sundog WWTP, solids treatment and processing will be based on continuing with the existing technologies of gravity belt thickening of waste activated sludge, anaerobic digestion of combined sludges, and centrifuge dewatering of digested sludge.

The existing belt filter press dewatering facility has reached the end of its useful life and should be replaced with a new solids dewatering building. For purposes of alternatives evaluation, centrifuge dewatering is assumed since this matches the recent technology added to the Airport WRF. However, when the plant is expanded, it is recommended that alternative methods of dewatering be evaluated during the preliminary design phase of the project.

For the purposes of this evaluation, the sludge generation rates for the MLE activated sludge and MBR activated sludge options have been assumed to be equivalent. In practise the MBR system operates at longer sludge ages and therefore achieve some additional aerobic stabilization of waste activated sludge.

Average and maximum month sludge production values were calculated for Phase 1 and the ultimate flows for Sundog WWTP as shown in Tables 5S.6 and 5S.7.

Table 5S.4 Primary Effluent Equalization Details Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies		
Parameter	**Value**	**Unit**
Equalization Volume	9.0	MG
Number of Basins	2	#
Volume in Each Basin, MG	4.5	MG
Basin Side Water Depth	20	ft
Total Basin Area	60,200	ft^2
Basin Type	Concrete / Covered	
Basin Cleaning	Mechanical mixing and hydrant washdown	

Table 5S.5 Equalization Basin Return Pump Station Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies		
Parameter	**Submersible Pumps**	**Unit**
Maximum Return Rate	2	mgd
Number of Pumps	2	(N+1)
Pump capacity (each)	2	mgd
Motor Control	VFD	Fixed/VFD
Motor Size	40	Hp
Number of Mixing Pumps	2	(N+1)
Motor Size	15	Hp

Table 5S.6 Sludge Production Design Criteria for Phase 1 Flows (3.6 mgd)
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameter	Unit	Volatile Solids	Total Solids
Primary Sludge Production Rate	lbs/d		
Average Month		7,179	8,158
Maximum Month		14,357	16,315
Waste Activated Sludge Production Rate	lbs/d		
Average Month		2,903	3,625
Maximum Month		6,870	8,482
Total Solids Production Rate	lbs/d		
Average Month		10,082	11,783
Maximum Month		12,227	24,797
WAS & PS Solids Concentration (after thickening)	%TS		5%
Total Flow to Digesters	mgd		
Average Month			0.028
Maximum Month			0.059

Table 5S.7 Sludge Production Design Criteria for Ultimate Flows (5.4 mgd)
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameter	Unit	Volatile Solids	Total Solids
Primary Sludge Production Rate	lbs/d		
Average Month		10,768	12,236
Maximum Month		21,536	24,473
Waste Activated Sludge Production Rate	lbs/d		
Average Month		4,354	5,482
Maximum Month		10,389	12,816
Total Solids Production Rate	lbs/d		
Average Month		15,122	17,718
Maximum Month		31,925	37,289
WAS & PS Solids Concentration (after thickening)	%TS		5%
Total Flow to Digesters	mgd		
Average Month			0.041
Maximum Month			0.089

Waste activated and primary volatile solids will be stabilized through anaerobic sludge digestion. In order to ensure compliance with conventional design guidelines for volatile solids loading and EPA 503B requirements for Class B sludge, digestion capacity must be increased. Digested sludge will be dewatered mechanically with centrifuges prior to land application. Design criteria for anaerobic digestion and centrifuge dewatering are presented in Tables 5S.8 and 5S.9. For the build-out maximum month load with one digester out of service, the digesters will not achieve EPA 503 Class B requirements. Further influent analysis will confirm if this maximum month loading condition is a valid scenario, at which point future digester capacity will need to be expanded.

Table 5S.8 Anaerobic Digester Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameter	Unit	Phase 1	Ultimate
Number of Digesters	#	3	4
Diameter	ft	50	50
Depth	ft	25	25
Volume per Digester	ft^3	49,000	49,000
Typical Volatile Solids Reduction	%	45%	45%
Total Volatile Solids Load - Average	lbs/d	10,082	15,122
Total Volatile Solids Load - Max Month	lbs/d	21,201	31,925
Thickened Sludge Flow - Average	mgd	0.028	0.042
Thickened Sludge Flow - Max Month	mgd	0.059	0.089
Volatile Solids Loading Rate (all in operation)	lbs VSS/ft^3/d		
Average Month		0.07	0.08
Maximum Month		0.14	0.16
Volatile Solids Loading Rate (1 OOS)	lbs VSS/ft^3/d		
Average Month		0.10	0.10
Maximum Month		0.22	0.22
Hydraulic Retention Time (all in operation)	Days		
Average Month		38.9	34.5
Maximum Month		18.5	16.4
Hydraulic Retention Time (one OOS)	Days		
Average Month		25.9	25.9

Table 5S.9 Digested Sludge Dewatering Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameter	Unit	Phase 1	Ultimate
Number of Centrifuges (one standby)	#	2	2
Operations Schedule	days/week	5	5
Centrifuge Capacity (Maximum)	gpm	150	150
Digested Solids Production	Lbs/d		
Average operating week		10,144	15,279
Maximum operating week		21,343	32,091
Digested Solids Flow	mgd		
Average operating Day		0.040	0.059
Maximum operating Month		0.083	0.125
Digested Sludge Storage for Max Month	Million gallons	0.12	0.18
Centrifuge Operation	Hrs/day		
Average operating week		4.4	6.6
Maximum operating week		9.3	13.9

6.0 ALTERNATIVE 1 – CONVENTIONAL MLE

6.1 Primary Treatment

Primary clarifiers will be installed for removal of settleable solids and particulate BOD_5 from the raw wastewater stream. Primary clarifiers are designed using surface overflow rates (SOR), and tank depths for retention and storage of settled solids. The maximum SOR for peak flow with one unit out of service will be less than 2,000 - 3,000 gpd/ft^2. Primary clarifiers have been sized with the assumption that both clarifiers will be available for service during the peak day event but only one clarifier needs to be in service for the maximum month flow event. A primary sludge pump station will be provided to convey primary sludge solids to anaerobic digesters. Design criteria for primary clarifiers and a primary sludge pump station are presented in Tables 5S.10 and 5S.11.

Table 5S.10 Primary Clarifier Technical Details
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

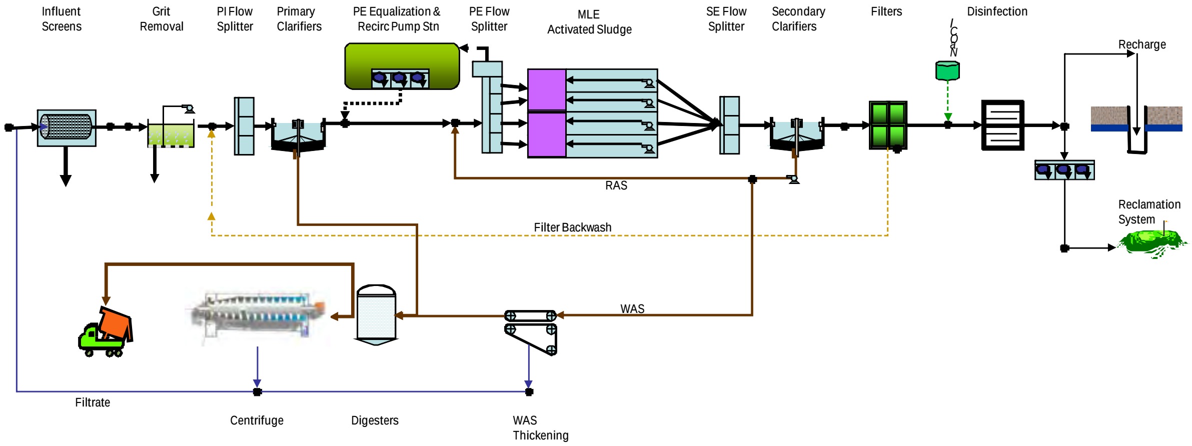
Parameter	Units	All in Service	One Out of Service
Peak Day Flow	**mgd**	**17.8**	
Maximum Month Flow	**mgd**		**10.8**
Number	units	2	1
Maximum Hydraulic Loading :	gpd/ft^2	2,313	2,806
Type		Circular	Circular
Diameter	ft	70	70
Depth	ft	12	12
Cone Slope (1:X)	ft:ft	12	12
Total Operating Volume	ft^3	99,846	49,923
Hydraulic Residence Time	hrs	1.0	0.8

Table 5S.11 Primary Sludge Pump Station Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies		
Parameter		**Unit**
Pump Type	Progressive Cavity	
Maximum pump rate	0.5	mgd
Number of Pumps	3	(N+1)
Pump Capacity (each)	0.25	mgd
Motor Control	VFD	Fixed/VFD
Motor Size	20	Hp

6.2 Activated Sludge Process

Alternative 1 uses a Modified Ludzack Ettinger (MLE) activated sludge process for carbon removal, nitrification and denitrification. The existing oxidation ditch aeration basins will be split into two MLE activated sludge trains each and the existing primary clarifiers will be converted to 2 anoxic basins. In addition 1 new aeration basin will be constructed for the ultimate 5.4 mgd average annual flow. Effluent from two new primary clarifiers is split equally to one of the four MLE activated sludge basins. Wet weather flow is split to a primary effluent equalization system and returned to the aeration basins when influent flows subside. An internal low head, high volume recycle pump returns mixed liquor from the end of the aeration basin train to the anoxic zone at the head of the aeration basin for denitrification. Aeration blowers provide air to the activated sludge process through diffusers located in the aeration basins. The aerated MLSS is combined and split equally to three (one new) secondary clarifiers in Phase 1. Ultimately 4 secondary clarifiers will be provided. Settled sludge is recycled to the head of the aeration basin via return activated sludge (RAS) pumps. Surplus activated sludge is wasted to a waste activated sludge (WAS) thickening system prior to anaerobic digestion.

Figure 5S.5 shows the basic flow schematic for this process. Table 5S.12 provides activated sludge design criteria for Alternative 1.



ALTERNATIVE 1 MLE ACTIVATED SLUDGE AND FILTERS PROCESS FLOW DIAGRAM

FIGURE 5S.5

In Association with carollo

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

Table 5S.12 MLE Activated Sludge Design Criteria Technical Memorandum No. 5S - Sundog WWTP Alternative Treatment Technologies City of Prescott, Arizona				
Phasing	**Phase 1 – 3.6 mgd**		**Build-Out – 5.4 mgd**	
Aeration Basins Number	2 existing basins converted to 4 trains (2 trains per basin)		1 new basin	
Total Anoxic Volume, ft^3	87,000 (convert 2 existing primary clarifiers to anoxic basins)		43,500	
Total Oxic Volume, ft^3	350,000		175,000	
Sidewater Depth, ft	11		18	
Loading Conditions	**Summer MM**	**Winter MM**	**Summer MM**	**Winter MM**
Flow	3.6	7.2	5.4	10.8
All Basins in Service				
MLSS (mg/L)	3,300	4,100	3,200	4,250
Hydraulic residence time (hrs)	21.8	10.9	21.2	10.6
Temperature (C)	20	12.4	20	12.4
One Basin Train Out of Service				
MLSS (mg/L)	3,900		3,800	
Hydraulic residence time (hrs)	17.5		17.8	
Temperature (C)	20		20	

Conversion from the existing facility to MLE activated sludge will require blowers for diffuser aeration, mixers for the anoxic zones and nitrate recycle pumps for denitrification. The aeration, mixing and pumping requirements will drive electrical demand and energy costs. Aeration, mixing, and recycle pumping requirements for Alternative 1 are provided in Table 5S.13. Anoxic zone mixer sizing, as shown in Table 5S.13 is based on providing 0.25 horsepower per 1000 cubic feet (hp/1000 ft^3).

Table 5S.13 Activated Sludge Equipment Design Criteria
Technical Memorandum No. 5S - Sundog WWTP
Alternative Treatment Technologies
City of Prescott, Arizona

Anoxic Zone Mixing	
Existing Primary Clarifiers	2
Converted to Anoxic Basins, number	
Total number of anoxic zones	6
Number of mixers per anoxic zone	1
Mixer hp	10
MIxing intensity (Hp/1,000 ft^3)	0.23
New Anoxic Basins, number	2
Total number of anoxic zones	6
Mixer hp	10
MIxing intensity (Hp/1,000 ft^3)	0.25
Diffused Aeration	
Existing Oxidation Ditches Converted	2
To Aeration Basins, number	
Type of Diffusers	Fine Bubble
Sidewater Depth,ft	11
Diffuser Depth, ft	10
New Aeration Basins, number	2
Type of Diffusers	
Sidewater Depth,ft	18
Diffuser Depth, ft	17
Process Aeration Blowers	
Type of blowers	Multi-stage centrifugal
Maximum month air flow, scfm	11,400
Number/capacity existing blowers	4 (one Stand-by) @ 3,800 scfm
Number/capacity new blowers	3 @ 3,800 scfm
Mixed Liquor Recycle Pumps	
Existing Oxidation Ditches Converted	
To Aeration Basins	
Number mixed liquor recycle pumps	4
Pump capacity, gpm	2,500
New Aeration Basins	
Number mixed liquor recycle pumps	2
Pump capacity, gpm	2,500

6.3 Secondary Clarifiers and Sludge Pumping

For the MLE activated sludge process, the two existing secondary clarifiers will be reused and one new secondary clarifier will be constructed for the Phase I capacity and an additional new clarifier for the ultimate capacity. For the new enhanced WWTP, the design SVI selected was 130 mL/g. This SVI is readily achievable with anoxic selectors and occasional use of chemicals (poly aluminium chloride and NaOCl for bulking filament control). The solids loading rates at the maximum month condition with one clarifier out of service are not sustainable. All clarifiers must remain in service during maximum month flow periods. Secondary clarifier sizing required for Alternative 1 is provided in Table 5S.14. The critical design condition is during the ultimate maximum month conditions with one clarifier out of service.

Table 5S.14 Secondary Clarifiers Design Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Clarifiers in Service	**Phase 1 – 3.6 mgd**		**Build-Out – 5.4 mgd**	
Number	3		4	
Diameter, ft	80		80	
Sidewater depth	15		15	
Bottom slope	1:12		1:12	
Sludge Collectors	Spiral, full radius scum skimmer			
Motor hp	2		2	
Maximum Design MLSS	4,100		4,250	
All Clarifiers				
Overflow rate	Summer	Winter	Summer	Winter
Overflow rate (gpd/ft^2)	239	477	269	537
Solids loading rate, at RAS = 60% of Influent				
Solids Loading Rate (lb/day/ft^2)	13.1	26.1	15.2	30.5
One Clarifier OOS, all aeration basins in Service				
Overflow rate	Summer	Winter	Summer	Winter
Overflow rate (gpd/ft^2)	358	716	358	716
Solids loading rate, at RAS = 60% of AAD				
Solids Loading Rate (lb/day/ft^2)	19.6	39.2	20.3	40.6

The secondary clarifiers will require additional RAS/WAS pumping capacity. The firm pumping capacity of the RAS pump station will be 100% of the maximum month flow. The pumping rate will vary based on the influent flow rate and process conditions. The WAS pumping capacity is based on the ability to pump the required WAS flow for the maximum month conditions during a 12-hour period each day. Table 5S.15 provides a summary of the RAS/WAS pump station capacity.

Table 5S.15 RAS/WAS Pumps Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies			
Parameter	**Unit**	**RAS System**	**WAS System**
Number of Pumps	#	4	2
Pump Capacity (each)	mgd	2.5	0.2
Pump Head	ft	20	30
Motor Control	Fixed/VFD	VFD	VFD
Motor Size	Hp	30	10

6.4 Tertiary Filtration

As identified in TM7, the existing travelling bridge filters at the Sundog WWTP have experienced failures in the porous plates. Replacement of the filters as soon as possible was recommended. Disk filters were selected as the preferred alternative based on the evaluation conducted in TM7. The recommended design criteria for the new disk filters is shown in Table 5S.16.

Table 5S.16 Tertiary Filters Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies		
Clarifiers in Service	**Phase 1 – 3.6 mgd**	**Build-Out – 5.4 mgd**
Number of Units	3 (2+1)	4 (3+1)
Unit Design		
Number of disks per unit	11	11
Filtration area per disk	53.8	53.8
Surface Area per Unit	591.8	591.8
MM Hydraulic Loading Rate all in service (gpm/ft^2)	2.8	3.2
MM Hydraulic Loading Rate one out of service (gpm/ft^2)	4.3	4.3

6.5 Disinfection

For purposes of this evaluation, disinfection is assumed to be achieved by use of UV as is currently the practice at the Sundog WWTP. The existing system will require expansion and improvements beyond what is currently installed in order to achieve Arizona Class A+ water quality. The system is assumed to be an open-channel configuration utilizing the existing chlorine contact basin. The system design for Phase I and Ultimate are presented in Table 5S.17.

Table 5S.17 UV Disinfection Design Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Criteria	Phase 1 – 3.6 mgd	Ultimate – 5.4 mgd
Type	LPHO	LPHO
Number of Channels	2	2
Banks per Channel	3	4
Modules per Bank	14	16
Lamps per Module	8	8
Total Lamps	672	1024
Capacity per Channel, mgd	7.2	10.8

6.6 Alternative 1 Site Layout

A preliminary site layout for Alternative 1 is shown on Figure 5S.6.

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE
FIGURE 5S.6

SUNDOG WWTP
CITY OF PRESCOTT
JUNE 2010

7.0 ALTERNATIVE 2 – MEMBRANE BIOREACTOR (MBR)

7.1 Primary Treatment

Primary clarifiers are required for removal of settleable solids and particulate BOD_5 from the raw wastewater stream. For this alternative, the existing Sundog WWTP secondary clarifiers are no longer needed as the MBR system provides biological solids separation. Therefore the existing secondary clarifiers will be converted to primary clarifiers. Primary clarifiers are designed using surface overflow rates (SOR), and tank depths for retention and storage of settled solids. The maximum SOR for peak flow with one unit out of service will be less than 2,000 -3,000 gpd/ft^2. The converted primary clarifiers are assumed to both be available for service during the peak day event but only one clarifier needs to be in service for the maximum month flow event. Primary clarifier design criteria for Alternative 2 is presented in Table 5S.18.

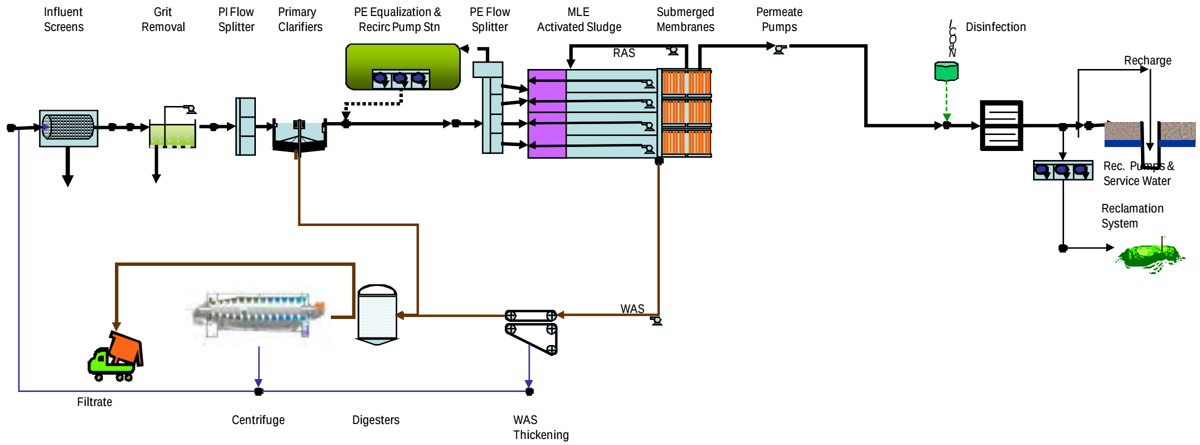
Table 5S.18 Primary Clarifier Technical Details
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Parameter	Units	All in Service	One Out of Service
Peak Day Flow	**mgd**	**17.8**	
Maximum Month Flow	**mgd**		**10.8**
Number	units	2	1
Maximum Hydraulic Loading :	gpd/ft^2	1,771	2,149
Type		Circular	Circular
Diameter	ft	80	80
Depth	ft	12	12
Cone Slope (1:X)	ft:ft	12	12
Total Operating Volume	ft^3	131,807	65,904
Hydraulic Residence Time	hrs	1.3	1.1

Table 5S.19 Primary Sludge Pump Station Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies		
Parameter	**Progressive Cavity Pumps**	**Unit**
Maximum pump rate	0.5	mgd
Number of Pumps	3	(N+1)
Pump Capacity (each)	0.25	mgd
Motor Control	VFD	Fixed/VFD
Motor Size	20	Hp

7.2 MBR Activated Sludge Process

Alternative 2 also uses a Modified Ludzack Ettinger (MLE) activated sludge process configuration for carbon removal, nitrification and denitrification. Primary sludge from the new primary clarifiers is pumped to the digesters for stabilization. The existing oxidation ditch aeration basins will be split into two MLE activated sludge trains each and the old primary clarifiers will be converted to 2 anoxic basins. Effluent from the new primary clarifiers is split equally to the MLE activated sludge basins. Wet weather flow is split to a primary effluent equalization system and returned when influent flows abate. An internal low head, high volume recycle pump returns mixed liquor from the end of the aeration basin train to the anoxic zone at the head of the aeration basin for denitrification. Aeration blowers provide air to the activated sludge through diffusers located in the aeration basins. The aerated MLSS is combined and split equally to three combined membrane filtration tanks in Phase 1. Ultimately 4 membrane filtration systems will be constructed. Concentrated sludge from the membrane filtration tanks is recycled to the head of the aeration basin via return activated sludge (RAS) pumps. Surplus activated sludge is wasted from the aeration basin to a waste activated sludge (WAS) thickening system prior to digestion.



ALTERNATIVE 2 MBR ACTIVATED SLUDGE PROCESS FLOW DIAGRAM

FIGURE 5S.7

In Association with carollo

CITY OF PRESCOTT

TECHNICAL MEMORANDUM NO. 5S – SUNDOG WWTP ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

Denitrification of the influent nitrogen that is oxidized occurs in the anoxic zone. Each aeration basin comprising two aeration trains will be connected to one converted primary clarifier that operates as an anoxic zone. This configuration facilitates redundancy and reliability when an aeration basin train is removed from service for diffuser replacement and repair. Nitrification is achieved in the oxic zone. Table 5S.20 indicates required process sizing.

Table 5S.20 MBR Activated Sludge Design Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Phasing	**Phase 1 – 3.6 mgd**		**Build-Out – 5.4 mgd**	
Number of Basins	2 basins converted 2 trains per basin		2 basins converted, 2 trains per basin	
Converted Ditch Side Water Depth (ft)	11		11	
Converted Primary Clarifier to Anoxic Basin Volume (ft)	43,500		43,500	
Converted Ditch Volume (ft^3)	175,000		175,000	
Converted Basin Volume (ft^3)	218,500		218,500	
Individual Train Aeration Volume (ft^3)	87,000		87,000	
Total Converted Basin Volume (ft^3)	437,000		437,000	
New Basin Side Water Depth (ft)	16		16	
Loading Condition	**Summer MM**	**Winter MM**	**Summer MM**	**Winter MM**
Flow	3.6	7.2	5.4	10.8
All basins in Service				
MLSS (mg/L)	3,300	4,100	4,950	6,150
Hydraulic residence time (hrs)	21.8	10.9	14.5	5.45
Temperature (C)	20	12.4	20	12.4
One aeration train Out of Service				
MLSS (mg/L)	3,900	5,310	5,850	7,965
Hydraulic residence time (hrs)	17.5	8.73	11.63	5.82
Temperature (C)	20	12.4	20	12.4

Microfiltration membranes will be used for simultaneous solids-liquid separation of the mixed liquor and filtration. Each membrane basin is sized to contain six 48-element membrane cassettes plus space to add two additional cassettes. Aeration of the membrane basins is required for scouring of the membranes. Each basin will also have a dedicated permeate pump. Mixed liquor enters the membrane basins via a common influent channel. At the opposite end of the each basin, the concentrated mixed liquor will flow over a weir to equalize the flow between the basins. Once collected in a common return channel, the mixed liquor will pass over an additional set of weirs to split the flow evenly to the four oxic zones of the secondary treatment basins. Draining of the membrane basins of mixed liquor for the purposes of chemical cleaning or maintenance within the membrane basins will be performed by drain pumps.

Identical to Alternative 1, conversion from the existing facility to MBR activated sludge will require blowers for diffuser aeration and mixers for the converted anoxic zones. Aeration requirements for Alternative 2 are provided in Table 5S.21. The aeration requirements are conservative as no credit has been taken for the oxygen that is dissolved into the MLSS in the membrane basins. The aeration requirements for the activated sludge system will be reduced during detailed design as a result of this aeration step. In zones that are not aerated, mechanical mixers are required for intimate contact between food and biomass in the cells. Mixer sizing is based on providing 0.25 horsepower per 1000 cubic feet (hp/1000 ft^3).

Flow at the end of each oxic zone will be recycled into the beginning of the anoxic zone by way of submersible mixed liquor recycle propeller pumps. The nominal rate of recycle is 4 times the ultimate MM flow or 10 mgd per basin train. Additionally, mixed liquor will be removed from the oxic zones and directed to the membrane basins via recirculation pumps. A majority of this pumped flow will return from the membranes to the beginning of the oxic zones by gravity flow. The pumps will be sized to continuously recirculate 4 times the peak membrane permeate flow or 10 mgd per membrane basin train.

Table 5S.21 MBR Membrane Basins Design Criteria
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

	Phase 1 - 3.6 mgd	**Ultimate - 5.4 mgd**
Number	6	8
Basin length, ea, ft	57.5	57.5
Basin width, ea, ft	10	10
Avg side water depth, ft	9.67	9.67
Total membrane volume, cf	54,617	54,617
Membrane cassettes per basin	6	6
Cassette Expansion Slots available	2	2
Membrane modules per cassette	48	48
Membrane area per module, sf	340	340
Installed Membrane area per basin, sf	97920	97920
Flux with 1 Train OOS		
Average Annual	7.4	7.9
Maximum Month	14.7	15.8
Peak Day	24.3	26.0
Flux all Trains Available		
Average Annual	6.1	6.9
Maximum Month	12.3	13.8
Peak Day	20.3	22.7
Scour Aeration Equipment		
Air requirements, scfm	10,260	13,680
Scour Blowers		
Number	2 + 1 standby	3 + 1 standby
Type	Multi-stage Centrifugal	
Rated capacity, scfm	5,700	5,700
Motor horsepower, ea	250	250
Permeate Pumps		
Type	End suction centrifugal	
Number per basin	1	
Total Number	6	
Capacity, ea. gpm	1,860	
Motor horsepower, ea	100	
Drain Pumps		
Type	Non-clog centrifugal	
Number	1 +1	
Capacity, ea. gpm	680	
Motor horsepower, ea	10	

Table 5S.22 MBR Aeration, Pumping and Mixing Equipment Design Criteria Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona Alternative Treatment Technologies	
Existing Oxidation Ditch Converted to Fine Bubble Aeration	
Type of Diffusers	Fine Bubble
Sidewater Depth, ft	11
Diffuser Depth, ft	10
Process Airflow at Maximum Month, air temperature = 110F, one train out of service, scfm	10,940
Blower Hp at 65% efficiency	375
Blower Hp each	125
Number of Blowers	4 (3+1)
Blower Discharge Pressure, ft	14
Mixed Liquor Recycle Pumps	
Mixed Liquor Recycle Pumps per basin	2
Mixed Liquor Recycle Pump capacity per basin train, mgd	10
Mixed Liquor Recycle Pump power, Hp	25
Converted Anoxic Zone: Number of Mixers per zone	1
Converted Anoxic Zone Mixer energy each (Hp)	10
Converted Anoxic Zone Mixing Intensity (Hp/1,000 ft^3)	0.23
Recirculation Pumps	
Type	Vertical propeller
Number per oxic zone	1
Total number	4
Capacity each, mgd	10
Motor horsepower, Hp	25
Motor drive	Adjustable frequency
Sludge Wasting Pumps	
Type	Non-clog centrifugal
Number per basin train	1
Capacity each, gpm	275
Motor horsepower, Hp	20
Motor drive	Adjustable frequency

7.3 MBR Site Layout

A preliminary site layout is shown on Figure 5S.8.

60' 30' 0 60' 120'
1"=120'
NEW HEADWORKS & SEPTAGE RECEIVING
NEW FINE SCREENING
CONVERT TO PRIMARY CLARIFIERS
NEW DISINFECTION
NEW DIGESTER
NEW GREASE RECEIVING
CONVERT EXIST DITCHES TO AERATION BASINS
NEW PS PUMP STATION
RELOCATE FLARE
NEW DIGESTER
NEW WAS THICKENING
NEW SOLIDS DEWATERING BUILDING
NEW MEMBRANE BASINS
POTENTIAL ADVANCED TREATMENT FACILITY
NEW BLOWER BUILDING
NEW FLOW EQ BASINS
NEW FLOW EQ BASINS
Legend
Phase 1 (3.6 mgd)
Ultimate (5.4 mgd)
Potential ATF (5.4 mgd)
In Association with
carollo
MEMBRANE (MBR) TREATMENT ALTERNATIVE
FIGURE 5S.8
SUNDOG WWTP
CITY OF PRESCOTT
JUNE 2010

8.0 COST COMPARISON

Table 5S.23 presents a summary of the present worth cost comparison of alternatives for the Sundog WWTP at ultimate (5.4 mgd) conditions. Details for both capital and O&M costs are provided in the appendix at the end of this TM.

Table 5S.23 Alternatives Detailed Cost Comparison (Ultimate)
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

Cost Type	Alternative 1 MLE	Alternative 2 MBR
Total Probable Construction Cost	$ 75,131,000	$ 74,963,000
Total Probable Present Worth O&M Cost	$ 35,614,000	$ 44,889,000
Total Probable Present Worth Cost	$ 110,745,000	$ 119,852,000

9.0 NON-ECONOMIC EVALUATION

The technology screening process also considered non-economic factors. These factors are subjective but may have a significant impact on the applicability of a technology. The non-economic factors identified for the process selection were consistency with existing plant process, process complexity, reliance on automation, effluent quality, foot print and process stability. Table 5S.24 shows a relative comparison of the treatment technologies with a score basis of 1 through 10 (higher value corresponding to more desirable). A multiplier was also applied to each of the non-economic factors to properly weigh those factors most important to the City. The treatment technology with the highest overall total score is the most attractive process based on a comparison of these non-economic factors.

Table 5S.24 Non-Economic Factor Comparison
Technical Memorandum No. 5S - Sundog WWTP, City of Prescott, Arizona
Alternative Treatment Technologies

	Weighting Factor	Alternative 1 - Conventional MLE		Alternative 2 - MBR	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
I&C Intensity	x 3	8	24	4	12
Compatibility w/AOP's	x 2	5	10	8	16
Sustainability Reuse	x 3	6	18	8	24
TOTAL		156		150	

Note:
(1) Comparison of non-economic factors where 10 = best and 1 = worst

10.0 LIQUID SECONDARY TREATMENT RECOMMENDATION

The costs and non-economic factors associated with MLE versus MBR treatment alternatives were presented and reviewed with City staff during project workshops. Based on the evaluation results and detailed discussions among project team members, MLE is the preferred treatment alternative for future expansions and improvements at the Sundog WWTP. Primary reasons for this recommendation include the following:

- MLE has a comparable capital cost and lower energy and O&M costs compared with MBR.
- MLE is consistent with the current treatment technology and is less complex with MBR.
- There is currently no water quality requirement for MBR treatment and MLE treatment does not preclude future advanced treatment facilities for emerging contaminants.
- MLE retains the ability to meet MBR effluent quality with the addition of advanced filtration facilities.

Appendix A
Cost Estimates

Final PW

BLACK & VEATCH

City of Prescott
Phase I/II Expansion
Sundog WWTP
B&V Project 164890

SUMMARY
June 16, 2010

	MLE	MBR
Probable Construction Cost	$ 75,131,000	$ 74,963,000
Present Worth O&M Cost	$ 35,614,000	$ 44,889,000
Total Present Worth Cost	**$ 110,745,000**	**$ 119,852,000**

Construction Summary

BLACK & VEATCH

City of Prescott
Phase I/II Expansion
Sundog WWTP
B&V Project 164890

OPINION OF
PROBABLE CONSTRUCTION COST
June 16, 2010

SUMMARY

	MLE			MBR		
BASE BID ITEMS	**Phase I**	**Phase II**	**Ultimate**	**Phase I**	**Phase II**	**Ultimate**
New Headworks Facilities	$ 2,926,000	$ -	$ 2,926,000	$ 3,266,000	$ -	$ 3,266,000
New Grease Receiving Station	$ 547,000	$ -	$ 547,000	$ 547,000	$ -	$ 547,000
Primary Clarifiers	$ 1,631,000	$ -	$ 1,631,000	$ 600,000	$ -	$ 600,000
New Primary Sludge Pump Station	$ 440,000	$ -	$ 440,000	$ 100,000	$ -	$ 100,000
Equalization Basin	$ 5,050,000	$ 5,050,000	$ 10,100,000	$ 5,050,000	$ 5,050,000	$ 10,100,000
Primary/Secondary Effluent Splitter Box	$ 283,000	$ -	$ 283,000	$ -	$ -	$ -
New Anoxic/Aeration Basins	$ -	$ 1,840,000	$ 1,840,000	$ -	$ -	$ -
Modifications to Existing Oxidation Ditches	$ 541,000	$ -	$ 541,000	$ 791,000	$ -	$ 791,000
New Blower Building	$ 783,000	$ 117,000	$ 900,000	$ -	$ -	$ -
Modifications to Existing Blower Building	$ 117,000	$ -	$ 117,000	$ 500,000	$ -	$ 500,000
New Membrane Treatment	$ -	$ -	$ -	$ 7,345,000	$ 1,200,000	$ 8,545,000
Secondary Clarifiers	$ 931,000	$ 931,000	$ 1,862,000	$ -	$ -	$ -
New RAS/WAS Pump Station	$ 603,000	$ 90,000	$ 693,000	$ -	$ -	$ -
Modify Existing RAS/WAS Pump Station	$ 90,000	$ -	$ 90,000	$ -	$ -	$ -
New Cloth Disk Filters	$ 2,166,000	$ -	$ 2,166,000	$ -	$ -	$ -
New UV Disinfection	$ 851,000	$ 65,000	$ 916,000	$ 511,000	$ 23,000	$ 534,000
New Gravity Belt Thickener	$ 300,000	$ 300,000	$ 600,000	$ 300,000	$ 300,000	$ 600,000
New Anaerobic Digesters	$ 1,282,000	$ 1,282,000	$ 2,564,000	$ 1,282,000	$ 1,282,000	$ 2,564,000
New Solids Handling Building	$ 2,877,000	$ -	$ 2,877,000	$ 2,877,000	$ -	$ 2,877,000
Subtotal	**$ 21,418,000**	**$ 9,675,000**	**$ 31,093,000**	**$ 23,169,000**	**$ 7,855,000**	**$ 31,024,000**
Sitework (10%)	$ 2,142,000	$ 968,000	$ 3,110,000	$ 2,317,000	$ 786,000	3,103,000
Electrical (20%)	$ 4,284,000	$ 1,935,000	$ 6,219,000	$ 4,634,000	$ 1,571,000	6,205,000
Instrumentation & Control (10%)	$ 2,142,000	$ 968,000	$ 3,110,000	$ 2,317,000	$ 786,000	3,103,000
HVAC/Plumbing (5%)	$ 1,071,000	$ 484,000	$ 1,555,000	$ 1,158,000	$ 393,000	1,551,000
Subtotal	**$ 31,057,000**	**$ 14,030,000**	**$ 45,087,000**	**$ 33,595,000**	**$ 11,391,000**	**$ 44,986,000**
General Requirements (15%)	$ 4,659,000	$ 2,105,000	$ 6,763,000	$ 5,039,000	$ 1,709,000	$ 6,748,000
Total Direct Costs	**$ 35,716,000**	**$ 16,135,000**	**$ 51,850,000**	**$ 38,634,000**	**$ 13,100,000**	**$ 51,734,000**
Contingencies (20%)	$ 7,143,000	$ 3,227,000	$ 10,370,000	$ 7,727,000	$ 2,620,000	$ 10,347,000
Subtotal	**$ 42,859,000**	**$ 19,362,000**	**$ 62,220,000**	**$ 46,361,000**	**$ 15,720,000**	**$ 62,081,000**
Contractor Overhead & Profit (15%)	$ 6,429,000	$ 2,904,000	$ 9,333,000	$ 6,954,000	$ 2,358,000	$ 9,312,000
Subtotal	**$ 49,288,000**	**$ 22,266,000**	**$ 71,553,000**	**$ 53,315,000**	**$ 18,078,000**	**$ 71,393,000**
Tax (5%)	$ 2,464,000	$ 1,113,000	$ 3,578,000	$ 2,666,000	$ 904,000	$ 3,570,000
TOTAL PROBABLE CONSTRUCTION COST	**$51,752,000**	**$23,379,000**	**$75,131,000**	**$55,981,000**	**$18,982,000**	**$74,963,000**

MLE Phase I

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Headworks				
Grease Receiving Station	N/A	LS	546,875	546,875
Septage Receiving Station	N/A	LS	500,000	500,000
Demolition				
Demo existing headworks	N/A	LS	100,000	100,000
Earthwork				
Excavation	2,000	cu yd	10.00	20,000
Compacted fill	446	cu yd	15.00	6,690
Concrete, cast in place				
Building Floor SOG + footings	520	cu yd	400.00	208,000
Headworks channel walls	243	cu yd	500.00	121,500
Headworks SOG	172	cu yd	400.00	68,800
Headworks suspended slab	4	cu yd	785.00	2,905
Equipment pad	10	cu yd	550.00	5,500
Install embedded accessories		Lump Sum		11,000
Building Superstructure				
Masonry	4,000	sq ft	18.00	72,000
Concrete Walls	60.0	cu yd	690.00	41,400
Roof				
1 1/2" Metal roof deck	7,000	sq ft	4.00	28,000
2" Ridgid insulation	7,000	sq ft	2.00	14,000
Standing seam metal roof panels	7,000	sq ft	8.00	56,000
Structural Framing				
Structural steel shapes	40.0	tons	4,000.00	160,000
Bar joists				
28LH08 x 55'	15	each	260.00	3,900
24LH05 x 37'	14	each	285.00	3,990
32LH11 x 66'	14	each	370.00	5,180
12k1 x 12'	16	each	140.00	2,240
2.5VS6 x 4'	7	each	100.00	700
Metal coping and flashing	480	lin ft	20.00	9,600
Doors incl frames and hardware				
Aluminum Entrance				
Double leaf w/sidelites and transom	2	each	3,250.00	6,500
Single leaf with sidelites	3	each	1,800.00	5,400
Rolling steel, 12'-0" x 12'-0"	5	each	8,200.00	41,000
Painting		Lump Sum		14,500
Metal				
Observation platforms	608	sq ft	80.00	48,640
Stairways (1) including railings	45	riser	225.00	10,125
Handrail, three rail aluminum pipe	572	lin ft	40.00	22,880
Al Grating	1,500	sq ft	40.00	60,000
Miscellaneous		Lump Sum		1,000
FRP Grating	165	sq ft	50.00	8,250
Equipment				
Parshall Flume	1	each	25,000.00	25,000
Headworks Equipment				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Channel grinder	3	each	54,500.00	163,500
Grit Removal				
PISTA basin equip	2	each	45,000.00	90,000
Grit pumps (2 + 1 shelf)	3	each	3,000.00	9,000
Grit washer/cyclone & screw (2 conct & 1	1	each	57,000.00	57,000
Coarse Screens	2	each	112,000.00	224,000
Washwater trough		Lump Sum		31,000
Maceracer screenings conditioner/dewater		Lump Sum		120,000
Total - Headworks				**2,926,075**
Primary Clarifiers				
Earthwork				
Structural excavation	10,200	cu yd	10.00	102,000
Compacted backfill	2,600	cu yd	15.00	39,000
Granular fill	290	cu yd	40.00	11,600
Substructure Piping				
42" Influent	120	lin ft	504.00	60,480
12" Drain	110	lin ft	144.00	15,840
6" Scum Suction	20	lin ft	80.00	1,600
6" Sludge Suction	110	lin ft	80.00	8,800
Concrete, cast-in-place				
Slab on grade	440	cu yd	400.00	176,000
Walls	380	cu yd	500.00	190,000
Suspended	50	cu yd	600.00	30,000
Fill	4	cu yd	250.00	1,000
Encasement	160	cu yd	325.00	52,000
Embedded accessories		Lump sum		9,000
Stairway	70	riser	250.00	17,500
Metal				
Scum Baffle & Weir	420	lin ft	80.00	33,600
Handrail, 3-rail	440	lin ft	45.00	19,800
Aluminum checkered plate	130	sq ft	35.00	4,550
Painting		Lump sum		26,000
Equipment				
Sludge Collector, 70' dia.	2	each	181,000.00	362,000
Special Construction				
Fabric Cover (Flat), 70' dia.	2	each	180,800.00	361,600
Mechanical				
Piping				
16" Foul Air	70	lin ft	224.00	15,680
6" Scum	80	lin ft	80.00	6,400
6" Sludge	90	lin ft	80.00	7,200
Plug Valve				
12" manual	2	each	4,000.00	8,000
6" electric actuated	4	each	6,500.00	26,000
6" manual	16	each	2,000.00	32,000

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Butterfly valve				
16" manual	2	each	2,900.00	5,800
Pipe supports		Lump sum		6,000
Miscellaneous		Lump sum		2,000
Total - Primary Clarifiers				**$1,631,450**
Primary Sludge Pump Station				
Earthwork				
Sructural excavation	60	cu yd	10.00	600
Compacted backfill	40	cu yd	15.00	600
Granular backfill	10	cu yd	40.00	400
Concrete, cast-in-place				
Slab on grade	15	cu yd	400.00	6,000
Building construction	2,500	sq.ft.	100.00	250,000
Monorail, 3-ton	1	each	18,000.00	18,000
Metal				
Grating	200	sq.ft.	45.00	9,000
Miscellaneous		Lump Sum		-
Doors, hollow metal				-
Hollow metal (single leaf)	3	each	1,400.00	4,200
Hollow metal (double leaf)	1	each	3,200.00	3,200
Rolling steel	1	each	5,500.00	5,500
Painting		Lump Sum		5,000
Equipment				
Primary Sludge Pumps	3	ea	15,000.00	45,000
Mechanical				
Ductile iron pipe	10,000	pound	4.25	42,500
Valves				
Plug				
8" manual	4	each	1,400.00	5,600
8" electric actuated	2	each	8,000.00	16,000
6" manual	3	each	1,105.00	3,315
6" electric actuated	1	each	6,500.00	6,500
Gate				
3" manual	1	each	400.00	400
Flow meter				
4" Mag meter	2	each	4,000.00	8,000
Painting		Lump sum		10,000
Total - Primary Sludge Pump Station				**$439,815**
Modifications to Existing Ox Ditches (MLE)				
Concrete, cast-in-place				
Walls	220	cu yd	500.00	110,000
Equipment				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Diffusers, Parksons HiOX & Appurtenances	1,183	each	75.00	88,725
MLR Pumps	4	each	25,000.00	100,000
Mechanical				
Piping				
Stainless steel (thin wall)				
Process air (above grade)				
18"	110	lin ft	216.00	$23,760
16"	650	lin ft	192.00	$124,800
14"	170	lin ft	168.00	$28,560
6"	180	lin ft	72.00	$12,960
Valves				
Butterfly,				
12" pneumatic	3	each	4,500.00	13,500
6" manual	12	each	1,500.00	18,000
Flow meters				
Flow meters, thermal dispersion type	9	each	4,070.00	36,630
Vortab, flow conditioner	9	each	2,795.00	25,155
Wall fittings	700	pound	10.00	7,000
Pipe supports		Lump Sum		13,500
Miscellaneous piping		Lump sum		18,000
Metal				
Aluminum checkered plate	16	sq ft	35.00	560
Miscellaneous demo and repairs		Lump Sum		20,000
Total - Modifications to Existing Oxidation ditches				**641,150**
Flow Equalization Basin				
Earthwork				
Structural excavation	60,000	cu yd	10.00	600,000
Compacted backfill	3,000	cu yd	15.00	45,000
Granular fill	800	cu yd	40.00	32,000
Concrete, cast-in-place				
Slab on grade	1,600	cu yd	400.00	640,000
Walls	1,950	cu yd	500.00	975,000
Embedded accessories		Lump sum		10,000
Stairway	70	riser	250.00	17,500
Equipment				
Primary Effluent Pumps	2	ea	56,000.00	112,000
Mixing Pumps	4	ea	42,000.00	168,000
Sluice Gates	8	ea	20,000.00	160,000
Miscellaneous Valves	1	LS	15,000.00	15,000
Other Miscellaneous	1	LS	25,000.00	25,000
Metals				
Cover 300' x 300'	90,000	sq ft	25.00	2,250,000
Total - Flow Equalization Basin				**5,049,500**

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Primary/Secondary Effluent Splitter Box				
Earthwork				
Structural excavation	1,730	cu yd	10.00	17,300
Compacted backfill	750	cu yd	15.00	11,250
Granular fill	45	cu yd	40.00	1,800
Concrete, cast-in-place				
Slab on grade	75	cu yd	400.00	30,000
Walls	150	cu yd	500.00	75,000
Mechanical				
Sluice Gates	6	ea	24,000.00	144,000
FRP Weirs	40	lin ft	80.00	3,200
Total - Primary/Secondary Effluent Splitter Box				**282,550**
Secondary Clarifiers				
Earthwork				
Structural excavation	6,400	cu yd	10.00	64,000
Compacted backfill	1,500	cu yd	15.00	22,500
Granular fill	190	cu yd	40.00	7,600
Substructure Piping				
42" Influent	60	lin ft	504.00	30,240
12" Drain	55	lin ft	144.00	7,920
6" Scum Suction	10	lin ft	80.00	800
6" Sludge Suction	55	lin ft	80.00	4,400
Concrete, cast-in-place				
Slab on grade	280	cu yd	400.00	112,000
Walls	215	cu yd	500.00	107,500
Suspended	30	cu yd	600.00	18,000
Fill	2	cu yd	250.00	500
Encasement	80	cu yd	325.00	26,000
Embedded accessories		Lump sum		10,000
Stairway	35	riser	250.00	8,750
Metal				
Scum Baffle & Weir	210	lin ft	80.00	16,800
Handrail, 3-rail	220	lin ft	45.00	9,900
Aluminum checkered plate	65	sq ft	35.00	2,275
Painting		Lump sum		10,000
Equipment				
Sludge Collector, 80' dia.	1	each	200,000.00	200,000
Special Construction				
Fabric Cover (Flat), 80' dia.	1	each	206,628.57	206,629
Mechanical				
Piping				
16" Foul Air	35	lin ft	224.00	7,840
6" Scum	40	lin ft	80.00	3,200
6" Sludge	45	lin ft	80.00	3,600

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Plug Valve				
12" manual	1	each	4,000.00	4,000
6" electric actuated	2	each	6,500.00	13,000
6" manual	8	each	2,000.00	16,000
Butterfly valve				
16" manual	1	each	2,900.00	2,900
Pipe supports		Lump sum		7,500
Miscellaneous		Lump sum		7,500
Total - Secondary Clarifiers				**931,354**
RAS/WAS Pump Station				
Earthwork				
Excavation	450	cu.yd.	10.00	4,500
Backfill	290	cu.yd.	15.00	4,350
Granular fill	52	cu.yd.	40.00	2,080
Concrete, cast-in-place				
Slab on grade	70	cu.yd.	400.00	28,000
Embedded accessories		Lump Sum		5,000
Building construction	1,800	sq.ft.	100.00	180,000
Monorail, 3-ton	1	each	18,000.00	18,000
Metal				
Grating	200	sq.ft.	45.00	9,000
Miscellaneous		Lump Sum		-
Doors, hollow metal				-
Hollow metal (single leaf)	3	each	1,400.00	4,200
Hollow metal (double leaf)	1	each	3,200.00	3,200
Rolling steel	1	each	5,500.00	5,500
Painting		Lump Sum		12,000
Equipment				
Vertical non-clog RAS pumps (Units 1&2)	2	each	13,000.00	26,000
Vertical non-clog RAS pumps (Units 3&4)	2	each	15,000.00	30,000
Vertical non-clog WAS pumps	2	each	13,000.00	26,000
Vertical non-clog Scum pumps	2	each	10,000.00	20,000
NPW Pump System	1	LS	70,000.00	70,000
Flow meter, magnetic				
6"	4	each	5,500.00	22,000
4"	1	each	3,800.00	3,800
Mechanical				
Process piping				
12" DIP	70	lin.ft.	144.00	10,080
10" DIP	10	lin.ft.	120.00	1,200
6" DIP	90	lin.ft.	72.00	6,480
4" DIP	60	lin.ft.	48.00	2,880
Plug valves				
12", manual	6	each	4,000.00	24,000
6", electric	3	each	6,500.00	19,500

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
6", manual	9	each	2,000.00	18,000
4", electric	1	each	2,100.00	2,100
4", manual	9	each	1,500.00	13,500
Check valves				
6"	6	each	2,000.00	12,000
4"	2	each	1,000.00	2,000
Pipe supports		Lump Sum		10,000
Wall fittings				
12"	4	each	1,050.00	4,200
6"	4	each	850.00	3,400
Total - RAS/WAS Pump Station				**602,970**
New Blower Building				
Earthwork				
Excavation	450	cu.yd.	10.00	4,500
Backfill	112	cu.yd.	15.00	1,680
Granular fill	170	cu.yd.	40.00	6,800
Concrete, cast-in-place				
Slab on grade	170	cu.yd.	400.00	68,000
Building Construction	2,500	sq.ft.	100.00	250,000
Doors				
Hollow #	6	each	1,400.00	8,400
Hollow metal (double leaf w/louver)	1	each	3,200.00	3,200
Rolling #	1	each	5,500.00	5,500
Equipment				
Multi-stage centrifugal blowers	4	each	82,250.00	329,000
In-line silencer, 24"	1	each	3,556.00	3,560
Bridge crane	1	each	35,000.00	35,000
Mechanical				
LWSP				
24"	40	lin.ft.	288.00	11,520
20"	90	lin.ft.	240.00	21,600
14"	70	lin.ft.	168.00	11,760
12"	85	lin.ft.	144.00	12,240
8"	50	lin.ft.	96.00	4,800
Valves				
24" BFV, manual	1	each	3,500.00	3,500
Pipe supports		Lump Sum		2,000
Total - Blower Building				783,000
Tertiary Filters				
Demolition				
Remove existing filters	1	each	45,000.00	45,000
Disposal to landfill		Lump Sum		15,000
Earthwork				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Sand Fill	135	cu yd	40.00	5,400
Concrete, cast-in-place				
Slab on grade	10	cu yd	400.00	4,000
Walls	10	cu yd	500.00	5,000
Painting		Lump Sum		3,000
Equipment				
Cloth disk filter	2	each	292,588.80	585,180
Mechanical				
Reject pipe, 3"	30	lin ft		900
Miscellaneous piping		Lump Sum	30.00	2,000
Total - Tertiary Filters				**665,000**
UV Disinfection Facilities Phase I				
Demolition				
Concrete Removal	N/A	Lump Sum	N/A	5,000
Earthwork				
Granular Fill	42	cu yd	40.00	1,680
Concrete, cast-in-place				
Slab on grade	9	cu yd	400.00	3,600
Wall	2	cu yd	500.00	1,000
Painting		Lump Sum		3,000
Equipment				
UV Equipment	1	each	700,000.00	700,000
Weir Gate + Level Control	1	each	65,000.00	65,000
Bridge Crane	1	each	74,200.00	74,200
Metal				
Sunshade	800	sq ft	15.00	12,000
Total - UV Disinfection Facilities				**$851,200**
New Anaerobic Digesters				
Earthwork				
Excavation	2,300	cu.yd.	10.00	23,000
Backfill	1,050	cu.yd.	15.00	15,750
Granular fill	35	cu.yd.	40.00	1,400
Concrete, cast-in-place				
Slab on grade	280	cu.yd.	400.00	112,000
Walls	80	cu.yd.	500.00	40,000
Building Construction	N/A	LS	N/A	250,000
Equipment				
Digester Mixing System	1	ea	120,000	120,000
Fixed Steel Digester Cover	1	ea	450,000	450,000
Sludge Heat Exchanger	1	ea	70,000	70,000
Sludge Recirculation Pumps	1	ea	30,000	30,000
Sludge Grinders	1	ea	20,000	20,000
Hot Water Booster Pumps	1	ea	20,000	20,000

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
OF/Transfer Pumps	1	ea	30,000	30,000
Piping	N/A	LS	N/A	100,000
Total - New Digesters				**1,282,150**
New Solids Handling Building				
Demolition				
Demo existing solids building	N/A	LS	100,000.00	100,000.00
Earthwork				
Excavation	1,000	cu.yd.	10	10,000
Backfill	200	cu.yd.	15	3,000
Granular fill	400	cu.yd.	40	16,000
Concrete, cast-in-place				
Slab on grade	420	cu.yd.	400	168,000
Building Construction	11,000	sq.ft.	100	1,100,000
Metal				
Observation platforms	320	sq.ft.	80	25,600
Stairs	12	riser	200	2,400
Grating	350	sq.ft.	45	15,750
Truck loading station structure & platform		Lump Sum		75,000
Miscellaneous		Lump Sum		2,000
Doors				
Hollow metal (single leaf)	7	each	1,400	9,800
Hollow metal (double leaf w/louver)	2	each	3,200	6,400
Rolling steel	8	each	5,500	44,000
Painting		Lump Sum		10,000
Equipment				
Centrifuges	2	each	420,000	840,000
Screw conveyor	5	each	60,000	300,000
Centrifuge feed pumps	2	each	35,000	70,000
Polymer feed equipment		Lump Sum		45,000
Flow meter, magnetic				
4"	2	each	3,800	7,600
Mechanical				
Process piping				
6" DIP	50	lin.ft.	72	3,600
4" DIP	235	lin.ft.	48	11,280
PVC piping				
3"	200	lin.ft.	15	3,000
Plug valves				
6"	3	each	2,000	6,000
4"	6	each	1,500	
Check valves				
4"	3	each	1,000	3,000
Total - Solids Building				**2,877,430**

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
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June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Modifications to Existing Ox Ditches (MBR)				
Concrete, cast-in-place				
Walls	20	cu yd	500.00	10,000
Equipment				
Diffusers, Parksons HiOX & Appurtenances	1,183	each	75.00	88,725
Mechanical				
Piping				
Stainless steel (thin wall)				
Process air (above grade)				
18"	110	lin ft	216.00	$23,760
16"	650	lin ft	192.00	$124,800
14"	170	lin ft	168.00	$28,560
6"	180	lin ft	72.00	$12,960
Valves				
Butterfly,				
12" pneumatic	3	each	4,500.00	13,500
6" manual	12	each	1,500.00	18,000
Flow meters				
Flow meters, thermal dispersion type	9	each	4,070.00	36,630
Vortab, flow conditioner	9	each	2,795.00	25,155
Wall fittings	700	pound	10.00	7,000
Pipe supports		Lump Sum		13,500
Miscellaneous piping		Lump sum		18,000
Metal				
Aluminum checkered plate	16	sq ft	35.00	560
Miscellaneous demo and repairs		Lump Sum		20,000
Total - Modifications to Existing Oxidation ditches				**441,150**

MLE Build-Out

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
New Anoxic/Aeration Basins				
Earthwork				
Structural excavation	12,000	cu yd	10.00	120,000
Compacted backfill	2,200	cu yd	15.00	33,000
Granular fill	480	cu yd	40.00	19,200
Substructure Piping				
42" Influent	200	lin ft	504.00	100,800
12" Drain	200	lin ft	144.00	28,800
6" Scum Suction	20	lin ft	80.00	1,600
6" Sludge Suction	200	lin ft	80.00	16,000
Concrete, cast-in-place				
Slab on grade	1,200	cu yd	400.00	480,000
Walls	600	cu yd	500.00	300,000
Suspended	90	cu yd	600.00	54,000
Fill	20	cu yd	250.00	5,000
Encasement	250	cu yd	325.00	81,250
Embedded accessories		Lump sum		10,000
Stairway	70	riser	250.00	17,500
Equipment				
Diffusers, Parksons HiOX & Appurtenances	2,366	each	32.00	75,712
MLR Pumps	4	each	25,000.00	100,000
Mechanical				
Piping				
Stainless steel (thin wall)				
Process air (above grade)				
18"	200	lin ft	216.00	43,200
16"	400	lin ft	192.00	76,800
14"	200	lin ft	168.00	33,600
6"	200	lin ft	72.00	14,400
Valves				
Butterfly,				
12" pneumatic	6	each	4,500.00	27,000
6" manual	24	each	1,500.00	36,000
Flow meters				
Flow meters, thermal dispersion type	18	each	4,070.00	73,260
Vortab, flow conditioner	18	each	2,795.00	50,310
Wall fittings	1,000	pound	10.00	10,000
Pipe supports		Lump Sum		13,500
Miscellaneous piping		Lump sum		18,000
Metal				
Aluminum checkered plate	40	sq ft	35.00	1,400
Total - New Anoxic/Aeration Basins				**1,840,332**
Flow Equalization Basin				
Earthwork				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Structural excavation	60,000	cu yd	10.00	600,000
Compacted backfill	3,000	cu yd	15.00	45,000
Granular fill	800	cu yd	40.00	32,000
Concrete, cast-in-place				
Slab on grade	1,600	cu yd	400.00	640,000
Walls	1,950	cu yd	500.00	975,000
Embedded accessories		Lump sum		10,000
Stairway	70	riser	250.00	17,500
Equipment				
Primary Effluent Pumps	2	ea	56,000.00	112,000
Mixing Pumps	4	ea	42,000.00	168,000
Sluice Gates	8	ea	20,000.00	160,000
Miscellaneous Valves	1	LS	15,000.00	15,000
Other Miscellaneous	1	LS	25,000.00	25,000
Metals				
Cover 300' x 300'	90,000	sq ft	25.00	2,250,000
Total - Flow Equalization Basin				**5,049,500**
Secondary Clarifiers				
Earthwork				
Structural excavation	6,400	cu yd	10.00	64,000
Compacted backfill	1,500	cu yd	15.00	22,500
Granular fill	190	cu yd	40.00	7,600
Substructure Piping				
42" Influent	60	lin ft	504.00	30,240
12" Drain	55	lin ft	144.00	7,920
6" Scum Suction	10	lin ft	80.00	800
6" Sludge Suction	55	lin ft	80.00	4,400
Concrete, cast-in-place				
Slab on grade	280	cu yd	400.00	112,000
Walls	215	cu yd	500.00	107,500
Suspended	30	cu yd	600.00	18,000
Fill	2	cu yd	250.00	500
Encasement	80	cu yd	325.00	26,000
Embedded accessories		Lump sum		10,000
Stairway	35	riser	250.00	8,750
Metal				
Scum Baffle & Weir	210	lin ft	80.00	16,800
Handrail, 3-rail	220	lin ft	45.00	9,900
Aluminum checkered plate	65	sq ft	35.00	2,275
Painting		Lump sum		10,000
Equipment				
Sludge Collector, 80' dia.	1	each	200,000.00	200,000
Special Construction				
Fabric Cover (Flat), 80' dia.	1	each	206,628.57	206,629
Mechanical				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Piping				
16" Foul Air	35	lin ft	224.00	7,840
6" Scum	40	lin ft	80.00	3,200
6" Sludge	45	lin ft	80.00	3,600
Plug Valve				
12" manual	1	each	4,000.00	4,000
6" electric actuated	2	each	6,500.00	13,000
6" manual	8	each	2,000.00	16,000
Butterfly valve				
16" manual	1	each	2,900.00	2,900
Pipe supports		Lump sum		7,500
Miscellaneous		Lump sum		7,500
Total - Secondary Clarifiers				**931,354**
RAS/WAS Pump Station				
Earthwork				
Excavation	450	cu.yd.	10.00	4,500
Backfill	290	cu.yd.	15.00	4,350
Granular fill	52	cu.yd.	40.00	2,080
Concrete, cast-in-place				
Slab on grade	70	cu.yd.	400.00	28,000
Embedded accessories		Lump Sum		5,000
Building construction	1,800	sq.ft.	100.00	180,000
Monorail, 3-ton	1	each	18,000.00	18,000
Metal				
Grating	200	sq.ft.	45.00	9,000
Miscellaneous		Lump Sum		-
Doors, hollow metal				-
Hollow metal (single leaf)	3	each	1,400.00	4,200
Hollow metal (double leaf)	1	each	3,200.00	3,200
Rolling steel	1	each	5,500.00	5,500
Painting		Lump Sum		12,000
Equipment				
Vertical non-clog RAS pumps (Units 1&2)	2	each	13,000.00	26,000
Vertical non-clog RAS pumps (Units 3&4)	2	each	15,000.00	30,000
Vertical non-clog WAS pumps	2	each	13,000.00	26,000
Vertical non-clog Scum pumps	2	each	10,000.00	20,000
NPW Pump System	1	LS	70,000.00	70,000
Flow meter, magnetic				
6"	4	each	5,500.00	22,000
4"	1	each	3,800.00	3,800
Mechanical				
Process piping				
12" DIP	70	lin.ft.	144.00	10,080
10" DIP	10	lin.ft.	120.00	1,200
6" DIP	90	lin.ft.	72.00	6,480

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
4" DIP	60	lin.ft.	48.00	2,880
Plug valves				
12", manual	6	each	4,000.00	24,000
6", electric	3	each	6,500.00	19,500
6", manual	9	each	2,000.00	18,000
4", electric	1	each	2,100.00	2,100
4", manual	9	each	1,500.00	13,500
Check valves				
6"	6	each	2,000.00	12,000
4"	2	each	1,000.00	2,000
Pipe supports		Lump Sum		10,000
Wall fittings				
12"	4	each	1,050.00	4,200
6"	4	each	850.00	3,400
Total - RAS/WAS Pump Station				**602,970**
New Blower Building				
Earthwork				
Excavation	450	cu.yd.	10.00	4,500
Backfill	112	cu.yd.	15.00	1,680
Granular fill	170	cu.yd.	40.00	6,800
Concrete, cast-in-place				
Slab on grade	170	cu.yd.	400.00	68,000
Building Construction	2,500	sq.ft.	100.00	250,000
Doors				
Hollow #	6	each	1,400.00	8,400
Hollow metal (double leaf w/louver)	1	each	3,200.00	3,200
Rolling #	1	each	5,500.00	5,500
Equipment				
Multi-stage centrifugal blowers	4	each	82,250.00	329,000
In-line silencer, 24"	1	each	3,556.00	3,560
Bridge crane	1	each	35,000.00	35,000
Mechanical				
LWSP				
24"	40	lin.ft.	288.00	11,520
20"	90	lin.ft.	240.00	21,600
14"	70	lin.ft.	168.00	11,760
12"	85	lin.ft.	144.00	12,240
8"	50	lin.ft.	96.00	4,800
Valves				
24" BFV, manual	1	each	3,500.00	3,500
Pipe supports		Lump Sum		2,000
Total - Blower Building				783,000

UV Disinfection Facilities Phase II

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Equipment				
UV Equipment	1	each	0.00	0
Replacement Weir Gate + Level Control	1	each	65,000	65,000
Total - UV Disinfection Facilities				**$65,000**
New Anaerobic Digesters				
Earthwork				
Excavation	2,300	cu.yd.	10.00	23,000
Backfill	1,050	cu.yd.	15.00	15,750
Granular fill	35	cu.yd.	40.00	1,400
Concrete, cast-in-place				
Slab on grade	280	cu.yd.	400.00	112,000
Walls	80	cu.yd.	500.00	40,000
Building Construction	N/A	LS	N/A	250,000
Equipment				
Digester Mixing System	1	ea	120,000	120,000
Fixed Steel Digester Cover	1	ea	450,000	450,000
Sludge Heat Exchanger	1	ea	70,000	70,000
Sludge Recirculation Pumps	1	ea	30,000	30,000
Sludge Grinders	1	ea	20,000	20,000
Hot Water Booster Pumps	1	ea	20,000	20,000
OF/Transfer Pumps	1	ea	30,000	30,000
Piping	N/A	LS	N/A	100,000
Total - New Digesters				**1,282,150**

MBR Phase I

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Headworks				
Grease Receiving Station	N/A	LS	546,875	546,875
Septage Receiving Station	N/A	LS	500,000	500,000
Demolition				
Demo existing headworks	N/A	LS	100,000	100,000
Earthwork				
Excavation	2,000	cu yd	10.00	20,000
Compacted fill	446	cu yd	15.00	6,690
Concrete, cast in place				
Building Floor SOG + footings	520	cu yd	400.00	208,000
Headworks channel walls	243	cu yd	500.00	121,500
Headworks SOG	172	cu yd	400.00	68,800
Headworks suspended slab	4	cu yd	785.00	2,905
Equipment pad	10	cu yd	550.00	5,500
Install embedded accessories		Lump Sum		11,000
Building Superstructure				
Masonry	4,000	sq ft	18.00	72,000
Concrete Walls	60.0	cu yd	690.00	41,400
Roof				
1 1/2" Metal roof deck	7,000	sq ft	4.00	28,000
2" Ridgid insulation	7,000	sq ft	2.00	14,000
Standing seam metal roof panels	7,000	sq ft	8.00	56,000
Structural Framing				
Structural steel shapes	40.0	tons	4,000.00	160,000
Bar joists				
28LH08 x 55'	15	each	260.00	3,900
24LH05 x 37'	14	each	285.00	3,990
32LH11 x 66'	14	each	370.00	5,180
12k1 x 12'	16	each	140.00	2,240
2.5VS6 x 4'	7	each	100.00	700
Metal coping and flashing	480	lin ft	20.00	9,600
Doors incl frames and hardware				
Aluminum Entrance				
Double leaf w/sidelites and transom	2	each	3,250.00	6,500
Single leaf with sidelites	3	each	1,800.00	5,400
Rolling steel, 12'-0" x 12'-0"	5	each	8,200.00	41,000
Painting		Lump Sum		14,500
Metal				
Observation platforms	608	sq ft	80.00	48,640
Stairways (1) including railings	45	riser	225.00	10,125
Handrail, three rail aluminum pipe	572	lin ft	40.00	22,880
Al Grating	1,500	sq ft	40.00	60,000
Miscellaneous		Lump Sum		1,000
FRP Grating	165	sq ft	50.00	8,250
Equipment				
Parshall Flume	1	each	25,000.00	25,000
Headworks Equipment				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Fine Screens	2	each	170,000.00	340,000
Channel grinder	3	each	54,500.00	163,500
Grit Removal				
PISTA basin equip	2	each	45,000.00	90,000
Grit pumps (2 + 1 shelf)	3	each	3,000.00	9,000
Grit washer/cyclone & screw (2 conct & 1	1	each	57,000.00	57,000
Coarse Screens	2	each	112,000.00	224,000
Washwater trough		Lump Sum		31,000
Maceracer screenings conditioner/dewater		Lump Sum		120,000
Total - Headworks				**3,266,075**
Flow Equalization Basin				
Earthwork				
Structural excavation	60,000	cu yd	10.00	600,000
Compacted backfill	3,000	cu yd	15.00	45,000
Granular fill	800	cu yd	40.00	32,000
Concrete, cast-in-place				
Slab on grade	1,600	cu yd	400.00	640,000
Walls	1,950	cu yd	500.00	975,000
Embedded accessories		Lump sum		10,000
Stairway	70	riser	250.00	17,500
Equipment				
Primary Effluent Pumps	2	ea	56,000.00	112,000
Mixing Pumps	4	ea	42,000.00	168,000
Sluice Gates	8	ea	20,000.00	160,000
Miscellaneous Valves	1	LS	15,000.00	15,000
Other Miscellaneous	1	LS	25,000.00	25,000
Metals				
Cover 300' x 300'	90,000	sq ft	25.00	2,250,000
Total - Flow Equalization Basin				**5,049,500**
UV Disinfection Facilities Phase I				
Demolition				
Concrete Removal	N/A	Lump Sum	N/A	5,000
Earthwork				
Granular Fill	42	cu yd	40.00	1,680
Concrete, cast-in-place				
Slab on grade	9	cu yd	400.00	3,600
Wall	2	cu yd	500.00	1,000
Painting		Lump Sum		3,000
Equipment				
UV Equipment	1	each	700,000.00	700,000
Weir Gate + Level Control	1	each	65,000.00	65,000
Bridge Crane	1	each	74,200.00	74,200
Metal				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost	Total Cost
			$	$
Sunshade	800	sq ft	15.00	12,000
Total - UV Disinfection Facilities				**$851,200**
New Anaerobic Digesters				
Earthwork				
Excavation	2,300	cu.yd.	10.00	23,000
Backfill	1,050	cu.yd.	15.00	15,750
Granular fill	35	cu.yd.	40.00	1,400
Concrete, cast-in-place				
Slab on grade	280	cu.yd.	400.00	112,000
Walls	80	cu.yd.	500.00	40,000
Building Construction	N/A	LS	N/A	250,000
Equipment				
Digester Mixing System	1	ea	120,000	120,000
Fixed Steel Digester Cover	1	ea	450,000	450,000
Sludge Heat Exchanger	1	ea	70,000	70,000
Sludge Recirculation Pumps	1	ea	30,000	30,000
Sludge Grinders	1	ea	20,000	20,000
Hot Water Booster Pumps	1	ea	20,000	20,000
OF/Transfer Pumps	1	ea	30,000	30,000
Piping	N/A	LS	N/A	100,000
Total - New Digesters				**1,282,150**
New Solids Handling Building				
Demolition				
Demo existing solids building	N/A	LS	100,000.00	100,000.00
Earthwork				
Excavation	1,000	cu.yd.	10	10,000
Backfill	200	cu.yd.	15	3,000
Granular fill	400	cu.yd.	40	16,000
Concrete, cast-in-place				
Slab on grade	420	cu.yd.	400	168,000
Building Construction	11,000	sq.ft.	100	1,100,000
Metal				
Observation platforms	320	sq.ft.	80	25,600
Stairs	12	riser	200	2,400
Grating	350	sq.ft.	45	15,750
Truck loading station structure & platform		Lump Sum		75,000
Miscellaneous		Lump Sum		2,000
Doors				
Hollow metal (single leaf)	7	each	1,400	9,800
Hollow metal (double leaf w/louver)	2	each	3,200	6,400
Rolling steel	8	each	5,500	44,000
Painting		Lump Sum		10,000

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Equipment				
Centrifuges	2	each	420,000	840,000
Screw conveyor	5	each	60,000	300,000
Centrifuge feed pumps	2	each	35,000	70,000
Polymer feed equipment		Lump Sum		45,000
Flow meter, magnetic				
4"	2	each	3,800	7,600
Mechanical				
Process piping				
6" DIP	50	lin.ft.	72	3,600
4" DIP	235	lin.ft.	48	11,280
PVC piping				
3"	200	lin.ft.	15	3,000
Plug valves				
6"	3	each	2,000	6,000
4"	6	each	1,500	
Check valves				
4"	3	each	1,000	3,000
Total - Solids Building				**2,877,430**
New Membrane Treatment				
Earthwork				
Excavation	9,000	cu yd	10.00	90,000
Compacted fill	3,420	cu yd	15.00	51,300
Engineered fill	180	cu yd	45.00	8,100
Concrete, cast in place				
Slab on grade and footings	960	cu yd	450.00	432,000
Membrane basin walls	1,020	cu yd	690.00	703,800
Suspended slabs	120	cu yd	785.00	94,200
Stairs	40	cu yd	800.00	32,000
Beams	20	cu yd	785.00	15,700
Columns	40	cu yd	690.00	27,600
Install embedded accessories		Lump Sum		30,000
Building Superstructure				
Masonry	5,524	sq ft	18.00	99,439
Cast-in-place Concrete Wall	60	cu yd	690.00	41,400
Roof				
1 1/2" Metal roof deck	13,980	sq ft	4.50	62,910
2" Ridgid insulation	13,980	sq ft	2.00	27,960
Standing seam metal roof panels	13,980	sq ft	8.50	118,830
Structural framing				
Structural steel shapes	60	tons	4,000.00	240,000
Bar joists	10	tons	4,000.00	40,000
16k2 x 25'	22	each		
16k4 x 23.5'	22	each		
20k6 x 30.75'	22	each		

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
16k2 x 16'	2	each		
16k3 x 19'	5	each		
Roof + structural steel framing subtotal				489,700
Metal coping and flashing	200	lin ft	20.00	4,000
Doors incl frames and hardware				
Aluminum Single Leaf	3	each	1,500.00	4,500
Painting		Lump Sum		15,000
Metal				
Handrail, three rail aluminum pipe	280	lin ft	50.00	14,000
Alum Check Plate	7,141	sq ft	40.00	285,640
Pipe Supports		Lump Sum		30,000
Misc Metals		Lump Sum		16,500
Equipment				
MBR System		Lump Sum		4,200,000
Booster Pump Skid		Lump Sum		50,000
Compressed Air Equipment		Lump Sum		26,500
4-Ton Bridge Crane - Long		Lump Sum		58,700
4-Ton Bridge Crane - Short		Lump Sum		35,000
Total - New Membrane Treatment				**7,344,779**
Modifications to Existing Ox Ditches (MBR)				
Concrete, cast-in-place				
Walls	20	cu yd	500.00	10,000
Equipment				
Diffusers, Parksons HiOX & Appurtenances	1,183	each	75.00	88,725
MLR Pumps	4	each	25,000.00	100,000
Mechanical				
Piping				
Stainless steel (thin wall)				
Process air (above grade)				
18"	110	lin ft	216.00	$23,760
16"	650	lin ft	192.00	$124,800
14"	170	lin ft	168.00	$28,560
6"	180	lin ft	72.00	$12,960
Valves				
Butterfly,				
12" pneumatic	3	each	4,500.00	13,500
6" manual	12	each	1,500.00	18,000
Flow meters				
Flow meters, thermal dispersion type	9	each	4,070.00	36,630
Vortab, flow conditioner	9	each	2,795.00	25,155
Wall fittings	700	pound	10.00	7,000
Pipe supports		Lump Sum		13,500
Miscellaneous piping		Lump sum		18,000
Metal				

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost	Total Cost
			$	$
Aluminum checkered plate	16	sq ft	35.00	560
Miscellaneous demo and repairs		Lump Sum		20,000
Total - Modifications to Existing Oxidation ditches				**541,150**

MBR Build-Out

BLACK & VEATCH

City of Prescott
Phase I/II Plant Expansion
Sundog WWTP
Probable Construction Cost
June 16, 2010

Item Description	Quantity	Unit	Unit Cost $	Total Cost $
Flow Equalization Basin				
Earthwork				
Structural excavation	60,000	cu yd	10.00	600,000
Compacted backfill	3,000	cu yd	15.00	45,000
Granular fill	800	cu yd	40.00	32,000
Concrete, cast-in-place				
Slab on grade	1,600	cu yd	400.00	640,000
Walls	1,950	cu yd	500.00	975,000
Embedded accessories		Lump sum		10,000
Stairway	70	riser	250.00	17,500
Equipment				
Primary Effluent Pumps	2	ea	56,000.00	112,000
Mixing Pumps	4	ea	42,000.00	168,000
Sluice Gates	8	ea	20,000.00	160,000
Miscellaneous Valves	1	LS	15,000.00	15,000
Other Miscellaneous	1	LS	25,000.00	25,000
Metals				
Cover 300' x 300'	90,000	sq ft	25.00	2,250,000
Total - Flow Equalization Basin				**5,049,500**
New Anaerobic Digesters				
Earthwork				
Excavation	2,300	cu.yd.	10.00	23,000
Backfill	1,050	cu.yd.	15.00	15,750
Granular fill	35	cu.yd.	40.00	1,400
Concrete, cast-in-place				
Slab on grade	280	cu.yd.	400.00	112,000
Walls	80	cu.yd.	500.00	40,000
Building Construction	N/A	LS	N/A	250,000
Equipment				
Digester Mixing System	1	ea	120,000	120,000
Fixed Steel Digester Cover	1	ea	450,000	450,000
Sludge Heat Exchanger	1	ea	70,000	70,000
Sludge Recirculation Pumps	1	ea	30,000	30,000
Sludge Grinders	1	ea	20,000	20,000
Hot Water Booster Pumps	1	ea	20,000	20,000
OF/Transfer Pumps	1	ea	30,000	30,000
Piping	N/A	LS	N/A	100,000
Total - New Digesters				**1,282,150**

O&M
Summary

BLACK & VEATCH

City of Prescott
Phase I/II Expansion
Sundog WWTP
B&V Project 164890

SUMMARY
June 16, 2010

COST TYPE		MLE	MBR	Sundog EQ
Annual Power Costs	$	1,133,000	1,448,000	184,000
Annual Chemical Costs	$	399,000	444,000	56,000
Annual Labor Costs	$	533,000	598,000	118,000
Annual Miscellaneous Costs	$	527,000	776,800	57,000
Probable Annual O&M Cost Total	**$**	**2,592,000**	**$ 3,267,000**	**$ 415,000**
Present Worth Factor 13.74				
Probable O&M Present Worth Cost		**$35,614,000**	**$44,889,000**	**$5,702,000**

MLE O&M

MLE - Build-out

ANNUAL POWER CONSUMTPION

FACILITY	Unit Qty.	Std. Unit	Unit Price	Total Cost
Headworks/Septage Receiving	302,466	kw-hr	$ 0.1	$ 30,000
Primary Clarifiers/PS Pump Station	161,654	kw-hr	$ 0.1	$ 16,000
Equalization Basin	32,657	kw-hr	$ 0.1	$ 3,000
Anoxic/Aeration Basins	3,135,099	kw-hr	$ 0.1	$ 314,000
Secondary Clarifiers and RAS/WAS Pump Station	431,076	kw-hr	$ 0.1	$ 43,000
Tertiary Filters	26,330	kw-hr	$ 0.1	$ 3,000
UV Disinfection	1,306,291	kw-hr	$ 0.1	$ 131,000
Sludge Thickening	205,741	kw-hr	$ 0.1	$ 21,000
Sludge Digesters	1,486,697	kw-hr	$ 0.1	$ 149,000
Solids Handling Building	886,553	kw-hr	$ 0.1	$ 89,000
Odor Control	1,500,000	kw-hr	$ 0.1	$ 150,000
Total Annual Power Cost				**$ 949,000**

ANNUAL CHEMICAL COSTS

CHEMICAL TYPE				
Filter Aid Polymer	1	LS	--	$ 5,000
Caustic, Hypochlorite, Ferrous Chloride	1	LS	--	$ 183,000
Emulsion Polymer, Active	1	LS	--	$ 128,000
Hydrochloric Acid	1	LS	--	$ 7,000
Diesel Fuel	1	LS	--	$ 15,000
Oils and Lubricants	1	LS	--	$ 5,000
Total Annual Chemical Cost				**$ 343,000**

ANNUAL LABOR COSTS (incl. benefits)

Operators	4	Staff	$ 60,000	$ 240,000
Mechanic	1	Staff	$ 65,000	$ 65,000
Supervisor	1	Staff	$ 75,000	$ 75,000
Administration	1	Staff	$ 35,000	$ 35,000
Total Annual Labor Cost				**$ 415,000**

ANNUAL MISCELLANEOUS COSTS

Disk Filter Maintenance	1	LS	--	$ 10,000
Annual UV Lamp Replacement Cost	1	LS	--	$ 92,000
Off-Site Sludge Disposal	8,100	Wet Tons	$ 15	$ 122,000
Off-Site Grit/Screenings Disposal	1	LS	--	$ 5,000
General Parts and Supplies	1	LS	--	$ 14,000
Communication Charges	12	Months	$ 1,000	$ 12,000
Potable Water Charges	12	Months	$ 400	$ 4,800
Major Process Parts Replacement	1	LS	--	$ 100,000
Centrifuge Maintenance Services Contract	1	LS	--	$ 30,000
Generator Maintenance Services Contract	1	LS	--	$ 50,000
Miscellaneous	1	LS	--	$ 30,000
Total Annual Miscellaneous Cost				**$ 469,800**

MBR O&M

MBR - Build-out

ANNUAL POWER CONSUMTPION

FACILITY	Unit Qty.	Std. Unit	Unit Price	Total Cost
Headworks/Septage Receiving	367,781	kw-hr	$ 0.1	$ 37,000
Primary Clarifiers/PS Pump Station	161,654	kw-hr	$ 0.1	$ 16,000
Equalization Basin	32,657	kw-hr	$ 0.1	$ 3,000
Anoxic/Aeration Basins	3,135,099	kw-hr	$ 0.1	$ 314,000
Membrane Treatment Facilities	3,969,383	kw-hr	$ 0.1	$ 397,000
UV Disinfection	875,215	kw-hr	$ 0.1	$ 88,000
Sludge Thickening	205,741	kw-hr	$ 0.1	$ 21,000
Sludge Digesters	1,486,697	kw-hr	$ 0.1	$ 149,000
Solids Handling Building	886,553	kw-hr	$ 0.1	$ 89,000
Odor Control	1,500,000	kw-hr	$ 0.1	$ 150,000
Total Annual Power Cost				**$ 1,264,000**

ANNUAL CHEMICAL COSTS

CHEMICAL TYPE				
Caustic, Hypochlorite, Ferrous Chloride	1	LS	--	$ 183,000
Emulsion Polymer, Active	1	LS	--	$ 128,000
Citric Acid	1	LS	--	$ 50,000
Hydrochloric Acid	1	LS	--	$ 7,000
Diesel Fuel	1	LS	--	$ 15,000
Oils and Lubricants	1	LS	--	$ 5,000
Total Annual Chemical Cost				**$ 388,000**

ANNUAL LABOR COSTS (incl. benefits)

Operators	4	Staff	$ 60,000	$ 240,000
Mechanic	1	Staff	$ 65,000	$ 65,000
Superintendent	1	Staff	$ 75,000	$ 75,000
Electrical/Instrumentation Tech.	1	Staff	$ 65,000	$ 65,000
Administration	1	Staff	$ 35,000	$ 35,000
Total Annual Labor Cost				**$ 480,000**

ANNUAL MISCELLANEOUS COSTS

Membrane Maintenance - replacement cost	1	LS	--	$ 160,000
Annual UV Lamp Replacement Cost	1	LS	--	$ 92,000
Off-Site Sludge Disposal	8,100	Wet Tons	$ 15	$ 122,000
Off-Site Grit/Screenings Disposal	1	LS	--	$ 5,000
General Parts and Supplies	1	LS	--	$ 14,000
Communication Charges	12	Months	$ 1,000	$ 12,000
Potable Water Charges	12	Months	$ 400	$ 4,800
Major Process Parts Replacement	1	LS	--	$ 200,000
Centrifuge Maintenance Services Contract	1	LS	--	$ 30,000
Generator Maintenance Services Contract	1	LS	--	$ 50,000
Miscellaneous	1	LS	--	$ 30,000
Total Annual Miscellaneous Cost				**$ 719,800**

EQ O&M

Sundog EQ

ANNUAL POWER CONSUMTPION

FACILITY	Unit Qty.	Std. Unit	Unit Price	Total Cost
Headworks/Septage Receiving	302,466	kw-hr	$ 0.1	$ 30,000
Primary Clarifiers/PS Pump Station	0	kw-hr	$ 0.1	$ -
Equalization Basin	38,100	kw-hr	$ 0.1	$ 4,000
Anoxic/Aeration Basins	0	kw-hr	$ 0.1	$ -
Secondary Clarifiers and RAS/WAS Pump Station	0	kw-hr	$ 0.1	$ -
Tertiary Filters	0	kw-hr	$ 0.1	$ -
UV Disinfection	0	kw-hr	$ 0.1	$ -
Sludge Thickening	0	kw-hr	$ 0.1	$ -
Sludge Digesters	0	kw-hr	$ 0.1	$ -
Solids Handling Building	0	kw-hr	$ 0.1	$ -
Odor Control	1,500,000	kw-hr	$ 0.1	$ 150,000
Total Annual Power Cost				**$ 184,000**

ANNUAL CHEMICAL COSTS

CHEMICAL TYPE				
Filter Aid Polymer	0	LS	--	$ -
Caustic, Hypochlorite, Ferrous Chloride	1	LS	--	$ 50,000
Emulsion Polymer, Active	1	LS	--	$ -
Hydrochloric Acid	0	LS	--	$ -
Diesel Fuel	1	LS	--	$ 5,000
Oils and Lubricants	1	LS	--	$ 1,000
Total Annual Chemical Cost				**$ 56,000**

ANNUAL LABOR COSTS (incl. benefits)

Operators	0.5	Staff	$ 60,000	$ 30,000
Mechanic	0.5	Staff	$ 65,000	$ 32,500
Supervisor	0.5	Staff	$ 75,000	$ 37,500
Administration	0.5	Staff	$ 35,000	$ 17,500
Total Annual Labor Cost				**$ 117,500**

ANNUAL MISCELLANEOUS COSTS

Disk Filter Maintenance	0	LS	--	$ -
Annual UV Lamp Replacement Cost	0	LS	--	$ -
Off-Site Sludge Disposal	0	Wet Tons	$ 15	$ -
Off-Site Grit/Screenings Disposal	1	LS	--	$ 5,000
General Parts and Supplies	1	LS	--	$ 5,000
Communication Charges	12	Months	$ 1,000	$ 12,000
Potable Water Charges	12	Months	$ 400	$ 4,800
Major Process Parts Replacement	1	LS	--	$ 10,000
Centrifuge Maintenance Services Contract	0	LS	--	$ -
Generator Maintenance Services Contract	1	LS	--	$ 15,000
Miscellaneous	1	LS	--	$ 5,000
Total Annual Miscellaneous Cost				**$ 56,800**

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 5A
Airport WRF Alternative Treatment Technologies

Final

In Association with

Project No. 164890

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City of Prescott

**TECHNICAL MEMORANDUM
NO. 5A**

**AIRPORT WRF ALTERNATIVE TREATMENT
TECHNOLOGIES EVALUATION**

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ES5A TM 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES

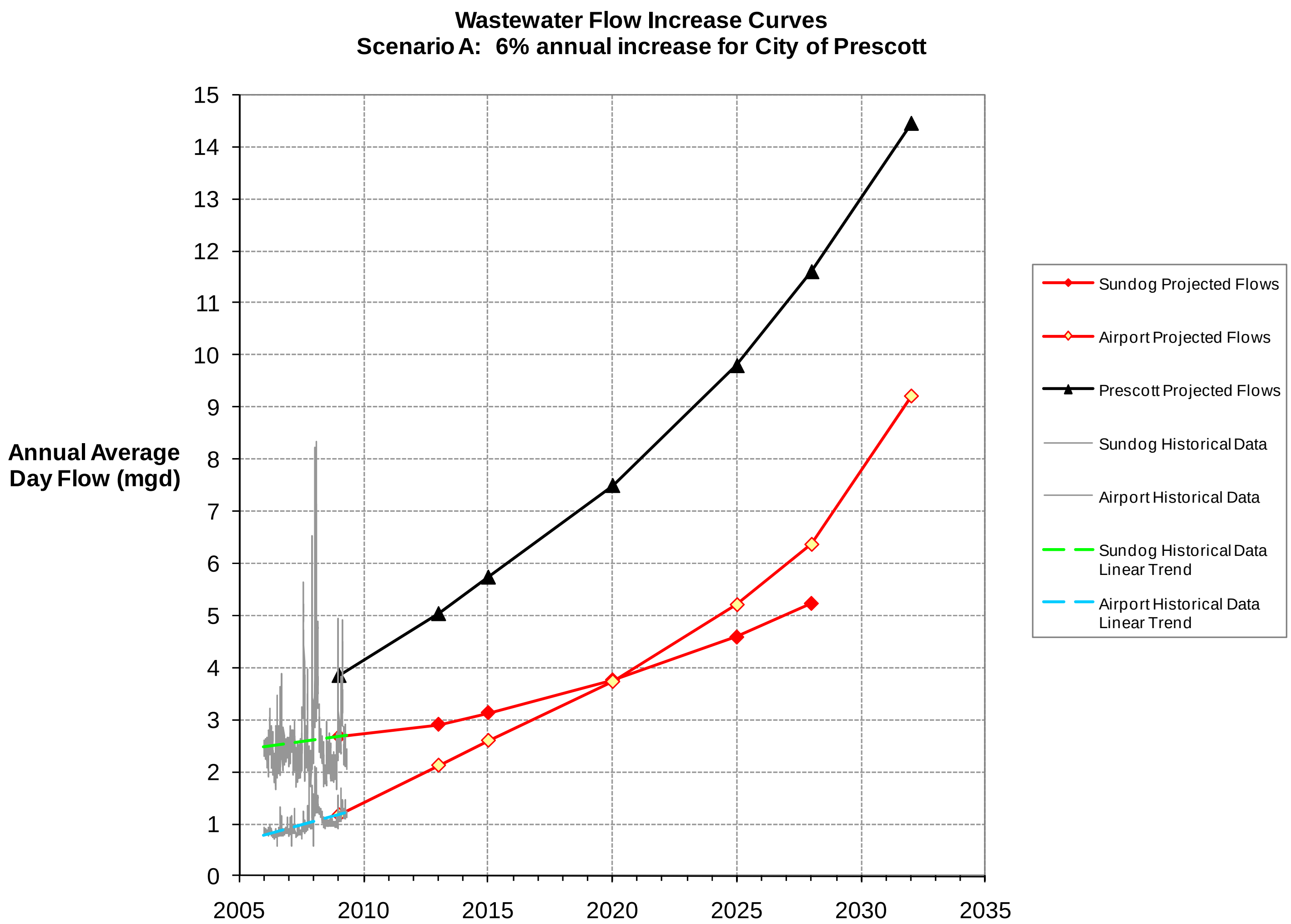
ES5A.1 Introduction

The purpose of this technical memorandum is to develop and evaluate treatment technology alternatives for the Airport WRF. The alternatives evaluation is based on a two-step approach. First, an initial screening of alternatives is carried out in order to identify the alternatives that are carried forward for detailed evaluation. Second, a detailed evaluation is performed based on a comparison of life-cycle costs and other non-economic factors. Site layouts and the costs associated with each treatment alternative for the projected Phase 1 and buildout conditions are presented for the Airport WRF.

ES5A.2 Planning Conditions

Wastewater flow projections for the Airport WRF were developed in an effort to estimate the timing of the expansions required at the facility. The approach to develop the flow projections was to establish aggressive and conservative flow increase scenarios in order to develop a range of possible flow increase curves that bracket the required timing for plant capacity expansions. Existing plant capacity was established in TM 3A.

Figure ES5A.1 and Figure ES5A.2 present the flow increase curves for the City of Prescott, the Sundog WWTP, and the Airport WRF. The aggressive flow increase scenario (Scenario A) is based on actual fast growth period in the City of Prescott, and was developed using historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. The conservative flow increase scenario (Scenario B) represents a conservative growth scenario, and is based on growth estimates in the several planning documents for the City of Prescott.



FLOW INCREASE CURVES – SCENARIO A (AGGRESSIVE)

FIGURE ES5A.1

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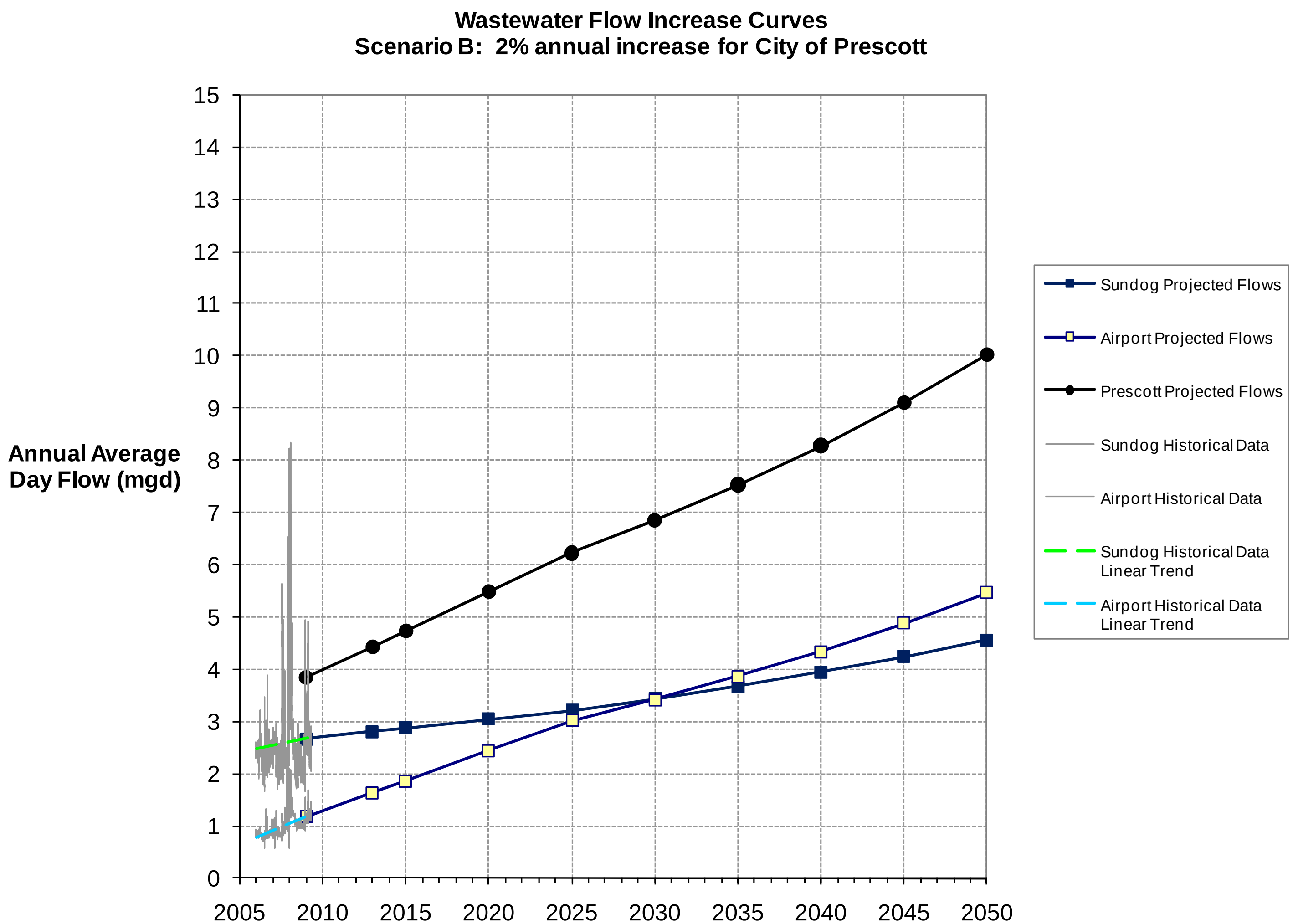
TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION



FLOW INCREASE CURVES – SCENARIO B (CONSERVATIVE)

FIGURE ES5A.2

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TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

The buildout annual average day flow (AADF) for the Airport WRF tributary area is 9.5 mgd (City of Prescott Wastewater Master Plan). For the purposes of this technology assessment and site master planning project, the buildout capacity was established at 9.6 mgd.

The capacity for each phase of the master planned capacity was established at 3.2 mgd (three treatment trains total). This capacity was established based on discussions with the City in several workshops, and it addresses the City's need of having additional treatment capacity beyond the permitted capacity of the existing plant (2.2 mgd). This Phase 1 capacity is more cost-effective than a four treatment train alternative, and it also provides a reasonable timeframe before the next capacity expansion is required.

Based on the flow increase scenarios presented above, Figure ES5A.3 shows the expected timing associated with a first phase of 3.2 mgd. It is estimated that with a Phase 1 capacity of 3.2 mgd, the Airport WRF would require the next expansion phase to be in service as early as the Year 2018 and as late as the Year 2028.

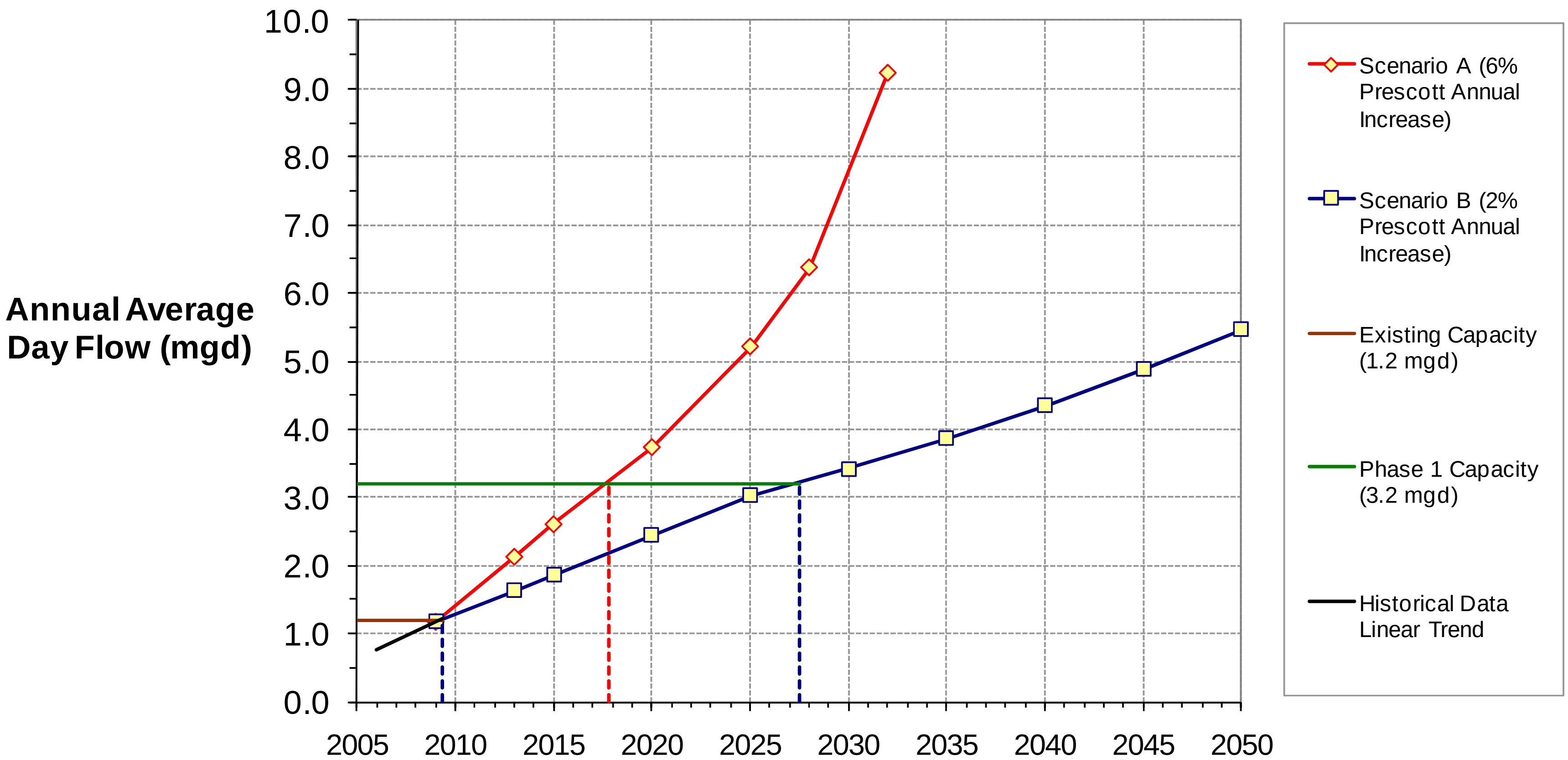
ES5A.3 Alternative Treatment Technologies Screening

For the initial evaluation of process alternatives, a full range of twelve treatment options were considered for completeness. While common process technologies at each plant were not a requirement of the master plan, there are significant advantages to the City with common or compatible processes. The full range of treatment alternatives were reviewed and discussed in project workshops with the City. There was a project team consensus that two alternatives should be brought forward for detailed evaluation:

- Alternative 1 – conventional activated sludge with Modified Ludzack-Ettinger Process (MLE) for biological nitrification and denitrification
- Alternative 2 – Membrane Bioreactor (MBR) with MLE for biological nitrification and denitrification

ES5A.4 Alternative 1 – Conventional MLE

Figure ES5A.4 presents the preliminary site plan for the conventional treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown outside the 350-feet internal setback from the property boundary.



FLOW INCREASE CURVES – AIRPORT WRF

FIGURE ES5A.3

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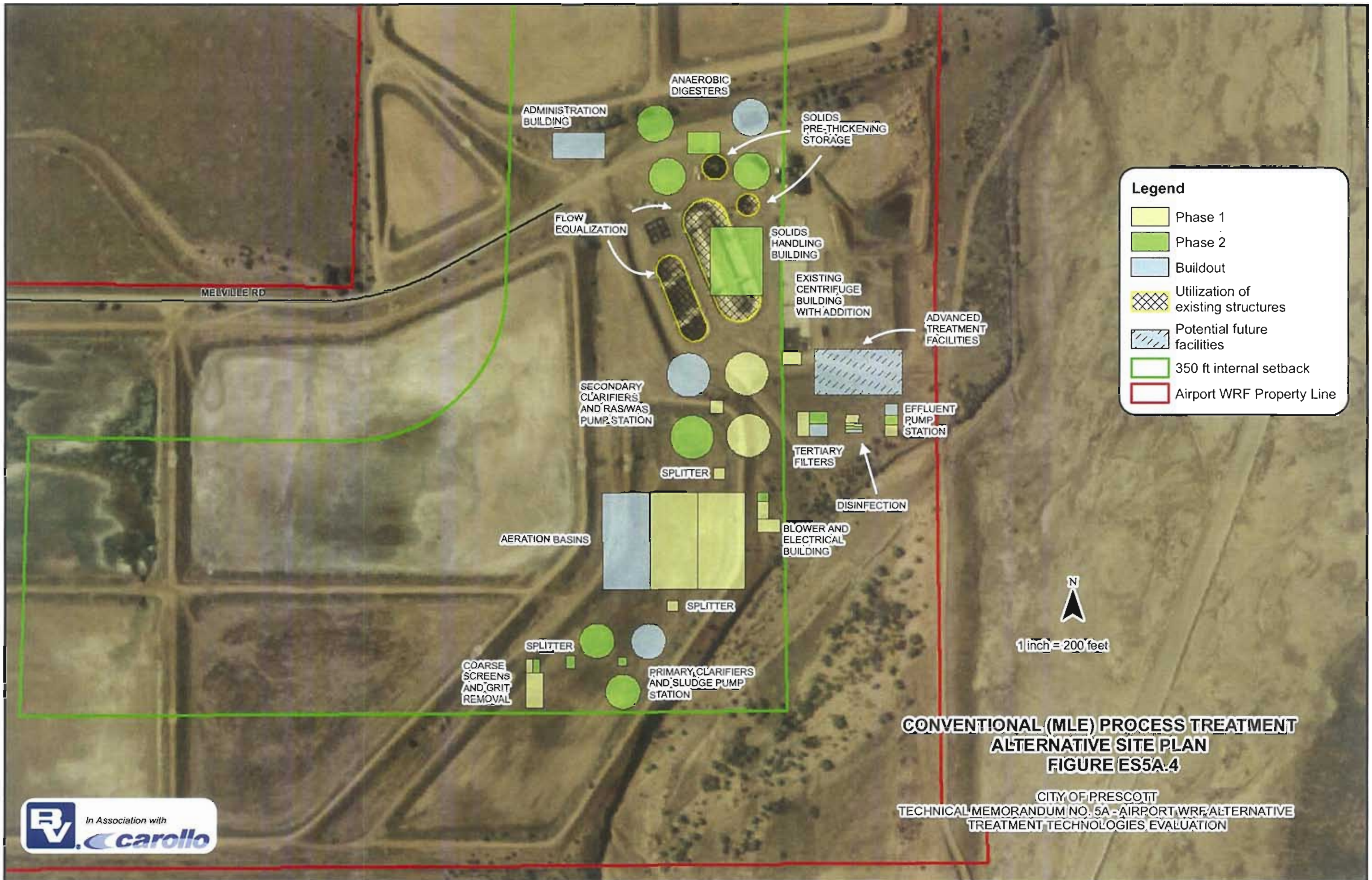
TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION



CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE SITE PLAN
FIGURE ES5A.4

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5A - AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

ES5A.5 Membrane Treatment Alternative

Figure 5A.5 presents the preliminary site plan for the membrane treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown outside the 350-feet internal setback from the property boundary.

ES5A.6 Alternatives Comparison

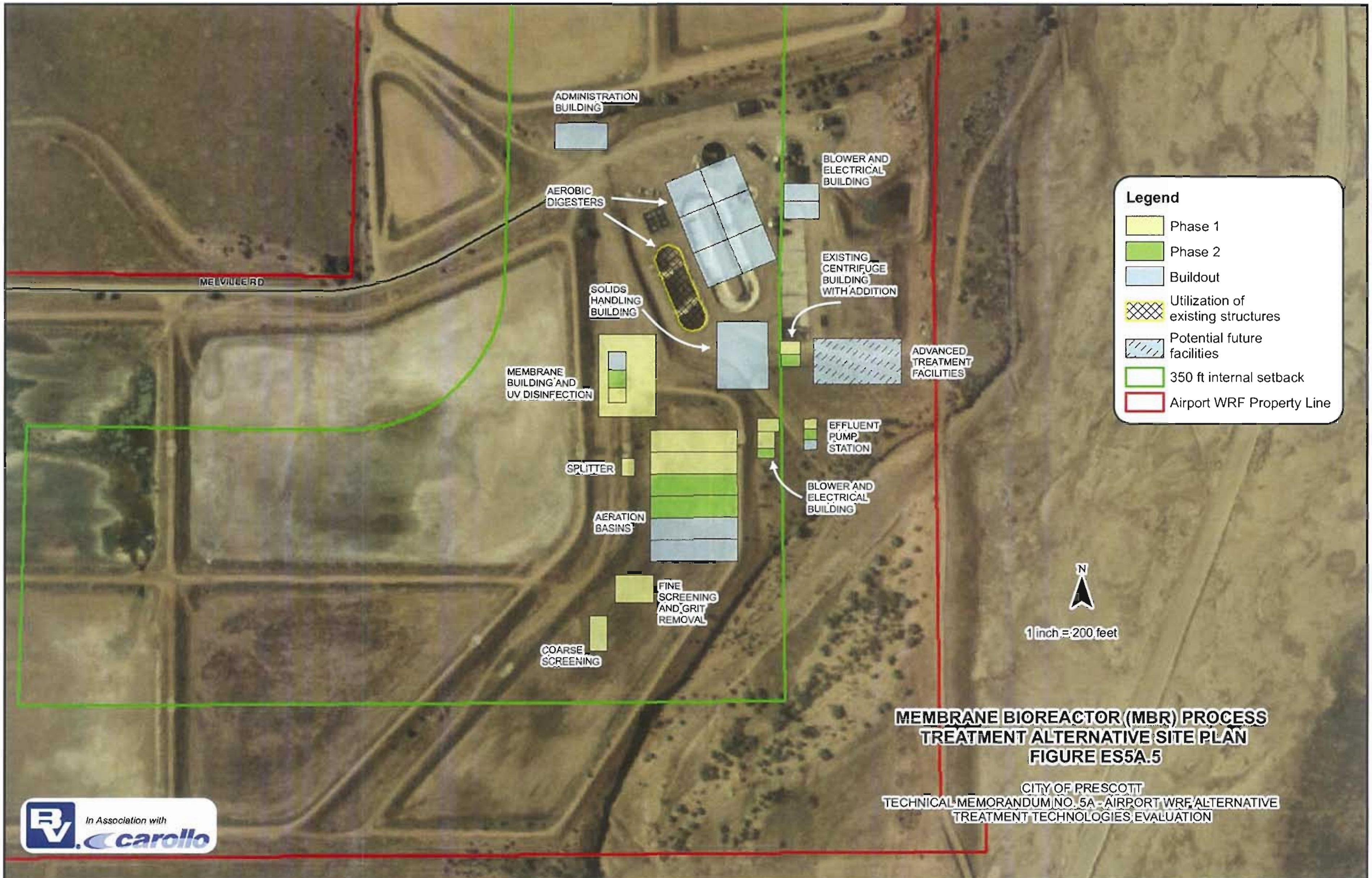
An economic comparison of the two treatment alternatives for buildout conditions is presented in Table ES5A.1.

Table ES5A.1 Treatment Alternatives Economic Comparison for Buildout (9.6 mgd)
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Criteria	Conventional (MLE) Treatment Alternative	Membrane (MBR) Treatment Alternative
Estimated Construction Cost	$121,864,000	$124,512,000
Annual Operations and Maintenance Costs	$3,631,000	$4,860,000
Total Life-Cycle Cost (1)	$171,744,000	$191,282,000

Note:
(1) As present value, assuming life-cycle period of 20 years, interest rate of 6 percent, and escalation rate of 2 percent.

The technology evaluation process also considered non-economic factors. Table ES5A.2 shows a relative comparison of the treatment technologies.



ADMINISTRATION BUILDING
AEROBIC DIGESTERS
BLOWER AND ELECTRICAL BUILDING
MELVILLE RD
SOLIDS HANDLING BUILDING
EXISTING CENTRIFUGE BUILDING WITH ADDITION
ADVANCED TREATMENT FACILITIES
MEMBRANE BUILDING AND UV DISINFECTION
EFFLUENT PUMP STATION
SPLITTER
BLOWER AND ELECTRICAL BUILDING
AERATION BASINS
FINE SCREENING AND GRIT REMOVAL
COARSE SCREENING
Legend
Phase 1
Phase 2
Buildout
Utilization of existing structures
Potential future facilities
350 ft internal setback
Airport WRF Property Line
N
1 inch = 200 feet
MEMBRANE BIOREACTOR (MBR) PROCESS
TREATMENT ALTERNATIVE SITE PLAN
FIGURE ES5A.5
CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 5A - AIRPORT WRF ALTERNATIVE
TREATMENT TECHNOLOGIES EVALUATION
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Table ES5A.2 Treatment Alternatives Non-Economic Comparison Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona					
		Alternative 1 – Conventional MLE		Alternative 2 – MBR	
Criteria	**Weighing Factor**	**Raw Score**	**Weighted Score**	**Raw Score**	**Weighted Score**
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
Instrumentation and Controls Intensity	x 3	8	24	4	12
Compatibility with Advanced Treatment Processes	x 2	5	10	8	16
Sustainability and Reuse	x 3	6	18	8	24
TOTAL OVERALL SCORE	-	-	**156**	**-**	**150**

Note:
(1) Comparison of non-economic factors where 1
0 = best and 1 = worst

ES5A.7 Liquid Secondary Treatment Recommendation

The economic evaluation presented herein shows that the capital costs of the conventional (MLE) process and the MBR process alternatives are practically the same given the accuracy of the cost estimates prepared for this effort. However, the conventional (MLE) process alternative has the lowest total life cycle costs, including operation and maintenance costs. The conventional (MLE) process also has a significantly lower Phase 1 capital cost compared to the MBR process alternative.

The non-economic evaluation presented in Section ES5A.6 shows that the conventional (MLE) process alternative had a higher score (better) than the MBR process alternative when considering non-economic factors.

Based on the results of the economic and non-economic evaluation, and discussions with City staff on project workshops, the recommended liquid secondary treatment technology for the Airport WRF is the conventional (MLE) activated sludge process.

The recommended process is compatible with advanced treatment processes with the addition of process units downstream of the MLE treatment process, such as membrane filtration and advanced oxidation processes. This flexibility allows the City to pursue advanced treatment in the future, depending on future requirements and regulations.

1.0 INTRODUCTION

This technical memorandum is part of the Master Planning, Design, and Local Limits project for the City of Prescott Airport Water Reclamation Facility (WRF) and Sundog Wastewater Treatment Plant (WWTP). This Technical Memorandum (TM) No. 5A addresses Task Group 500 Liquid Treatment Alternatives Evaluations, with the exception of Task 502 I/I Reduction Cost-Effectiveness Study, which is addressed in a separate document.

The purpose of this technical memorandum is to develop and evaluate treatment technology alternatives for the Airport WRF. The alternatives evaluation is based on a two-step approach. First, an initial screening of alternatives is carried out in order to identify the alternatives that are carried forward for detailed evaluation. Second, a detailed evaluation is performed based on a comparison of life cycle costs and other non-economic factors. Site layouts and the costs associated with each treatment alternative for the projected Phase 1 and buildout conditions are presented for the Airport WRF.

2.0 PLANNING CONDITIONS

2.1 Wastewater Flow Increase

Wastewater flow projections for the Sundog WWTP and Airport WRF were developed in an effort to estimate the timing of the expansions required at both facilities. The approach to develop the flow projections was to establish aggressive and conservative flow increase scenarios in order to develop a range of possible flow increase curves that provide a basis for determining the required capacities at each treatment facility. Existing plant capacities have been set by the increase in wastewater strength as referenced in TM No. 3A – Airport WRF Existing Conditions and TM No. 3S – Sundog WWTP Existing Conditions.

2.1.1 Scenario A – Aggressive Flow Increase

The aggressive flow increase scenario (Scenario A) was based on the historical influent flow trends at the Sundog WWTP and Airport WRF between 2006 and 2009. This scenario captures an actual fast growth period in the City of Prescott, and is considered representative of a possible aggressive flow increase scenario for the City's treatment facilities.

Influent flows to both facilities were added in order to determine the total wastewater flow increase in the City of Prescott. The annual percent wastewater flow increase for the City of Prescott based on influent flow data was calculated to be 6.1 percent for the period between January 2006 and April 2009.

Due to the different nature of the service areas for the Sundog WWTP and the Airport WRF, the percent flow increase is different for each plant. The Sundog WWTP service area is significantly more developed than the Airport WRF service area. Therefore, the rate of flow increase at the Sundog WWTP is expected to be slower than the rate of flow increase at the Airport WRF.

In order to develop the flow increase curves for each plant, it was assumed that 64 percent of the flow increase for the City is sent to the Airport WRF, and 36 percent is sent to the Sundog WWTP. Two reference points were used to determine the relative split of the City's flow increase to each of the two treatment facilities.

- Historical wastewater flow data between January 2006 and April 2009. Based on historical flow data, 67 percent of the flow increase for the City occurred at the Airport WRF, and 33 percent occurred at the Sundog WWTP.
- Buildout flow for each plant per the City's Wastewater Master Plan. Buildout flows for the Airport WRF and the Sundog WWTP are 9.5 mgd and 5.3 mgd, respectively. At buildout, 64 percent of the wastewater flow is treated at the Airport WRF and 36 percent of the flow is treated at the Sundog WWTP.

Table 5A.1 summarizes the historical flow data used to develop assumptions presented in this aggressive flow increase scenario. Figure 5A.1 presents the flow increase curves for the City of Prescott, the Sundog WWTP, and the Airport WRF.

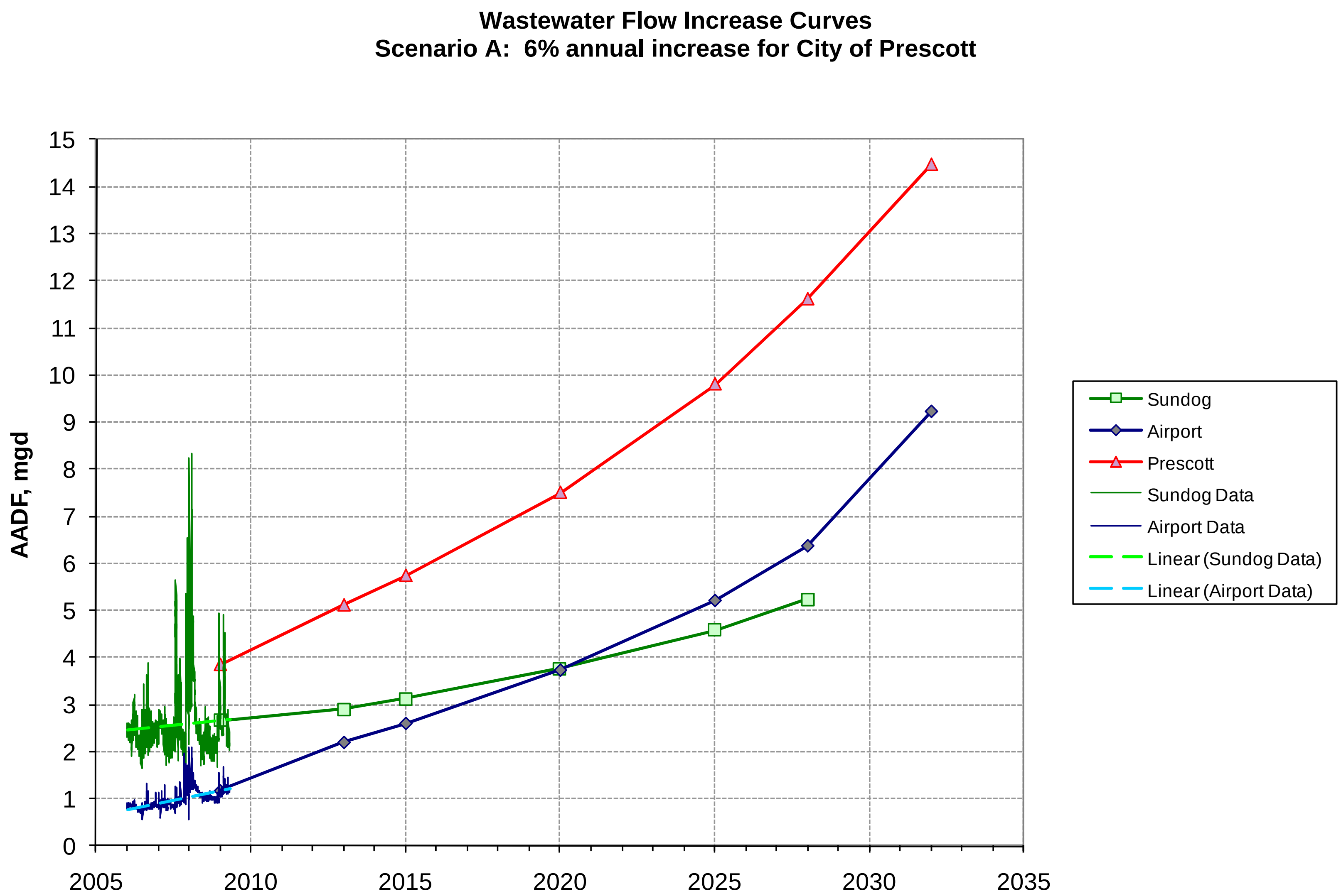
Table 5A.1 Historical Flow Increase at City of Prescott Treatment Facilities
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Criteria	Airport WRF	Sundog WWTP	Total
Influent Flow January 2006, mgd	0.772 (1)	2.470 (1)	3.242
Influent Flow April 2009, mgd	1.215 (1)	2.691 (1)	3.906
Annual Flow Increase, %	17.2	2.7	6.1
Flow increase 2006-2009, mgd	0.443	0.221	0.664
Fraction of Flow Increase	0.67	0.33	1.00

Notes:

(1) Based on linear trend of daily average flow data.

(2) Sundog influent flows include discharge flows from the Hassayampa Water Reclamation Plant (WRP) to the collection system. Annual average flows from the Hassayampa WRP are approximately 12,000 gallons per day of waste activated sludge from the activated sludge process (8,000 gpd between November-April, and 16,000 gpd between April-November).



FLOW INCREASE CURVES - SCENARIO A (AGGRESSIVE)

FIGURE 5A.1

2.1.2 Scenario B – Conservative Flow Increase

The conservative flow increase scenario (Scenario B) represents a moderate growth scenario. An annual flow increase of 2 percent was assumed to develop the wastewater flow increase curve for the City of Prescott. The assumption is based on growth estimates used in the following planning documents for the City of Prescott:

- 2003 Prescott General Plan, Ratified May 2004.
- Yavapai County General Plan, April 2003.
- Arizona Subcounty Population Projections. Arizona Department of Economic Security, Research Administration, Population Statistics Unit, December 2006.
- Wastewater Collection System Model Study, January 2008.

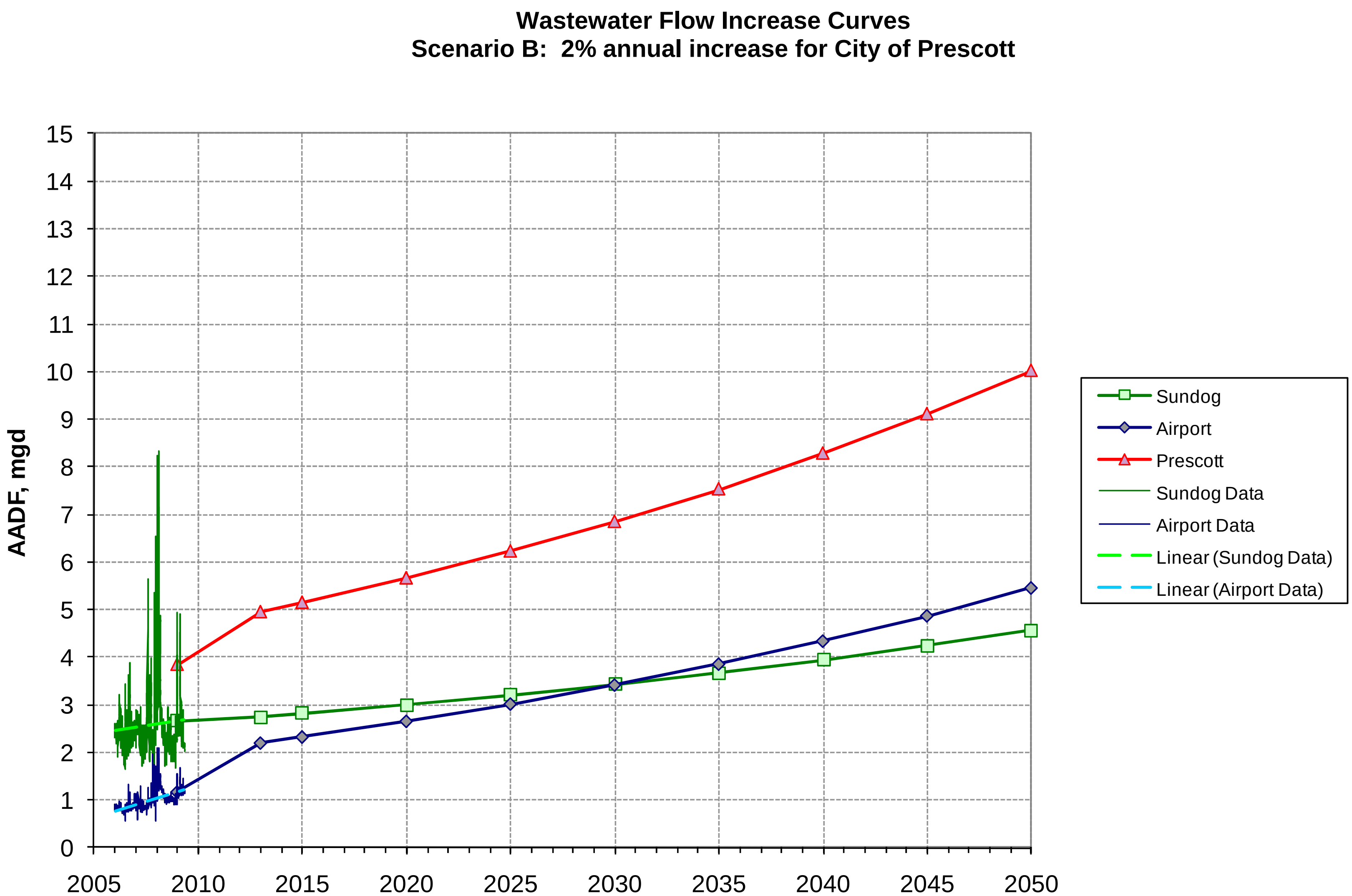
In order to develop the flow increase curves for each plant, it was assumed that 64 percent of the flow increase for the City is sent to the Airport WRF, and 36 percent is sent to the Sundog WWTP. This is the same assumption made for Scenario A, presented in Section 2.1.1. Figure 5A.2 presents the flow increase curves for the City of Prescott, the Sundog WWTP, and the Airport WRF.

2.1.3 Airport WRF Phasing

The buildout annual average day flow (AADF) for the Airport WRF tributary area is 9.5 mgd (City of Prescott Wastewater Master Plan). For the purposes of this technology assessment and site master planning project, the buildout capacity was established at 9.6 mgd.

Based on regulatory requirements, the City is required to have installed wastewater treatment capacity to issue plat approvals. Therefore, the City requires having sufficient additional capacity in the wastewater treatment facilities to allow for growth and development to occur in the City. Currently, the Airport WRF has a committed capacity approaching the permitted capacity of 2.2 mgd, and any significant capital investment at the plant should increase capacity beyond the permitted capacity of 2.2 mgd in order to allow growth and development. This is particularly important for the Airport WRF, because its service area is an area of growth within the City.

The capacity for each phase of the master planned capacity was established at 3.2 mgd (three treatment trains total). This capacity was established based on discussions with the City in several workshops, and it addresses the City's need of having additional treatment capacity beyond the permitted capacity of the existing plant (2.2 mgd). This Phase 1 capacity is more cost-effective than a four treatment train alternative, and it also provides a reasonable timeframe before the next capacity expansion is required.



FLOW INCREASE CURVES - SCENARIO B (AGGRESSIVE)

FIGURE 5A.2

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TECHNICAL MEMORANDUM NO. 5A – AIRPORT WRF ALTERNATIVE TREATMENT TECHNOLOGIES EVALUATION

Based on the flow increase scenarios presented in Sections 2.1.1 and 2.1.2 above, Figure 5A.3 shows the expected timing associated with a first phase of 3.2 mgd. It is estimated that with a Phase 1 capacity of 3.2 mgd, the Airport WRF would require the next expansion phase to be in service as early as the Year 2018 and as late as the Year 2028.

2.1.4 Sundog WWTP Phasing

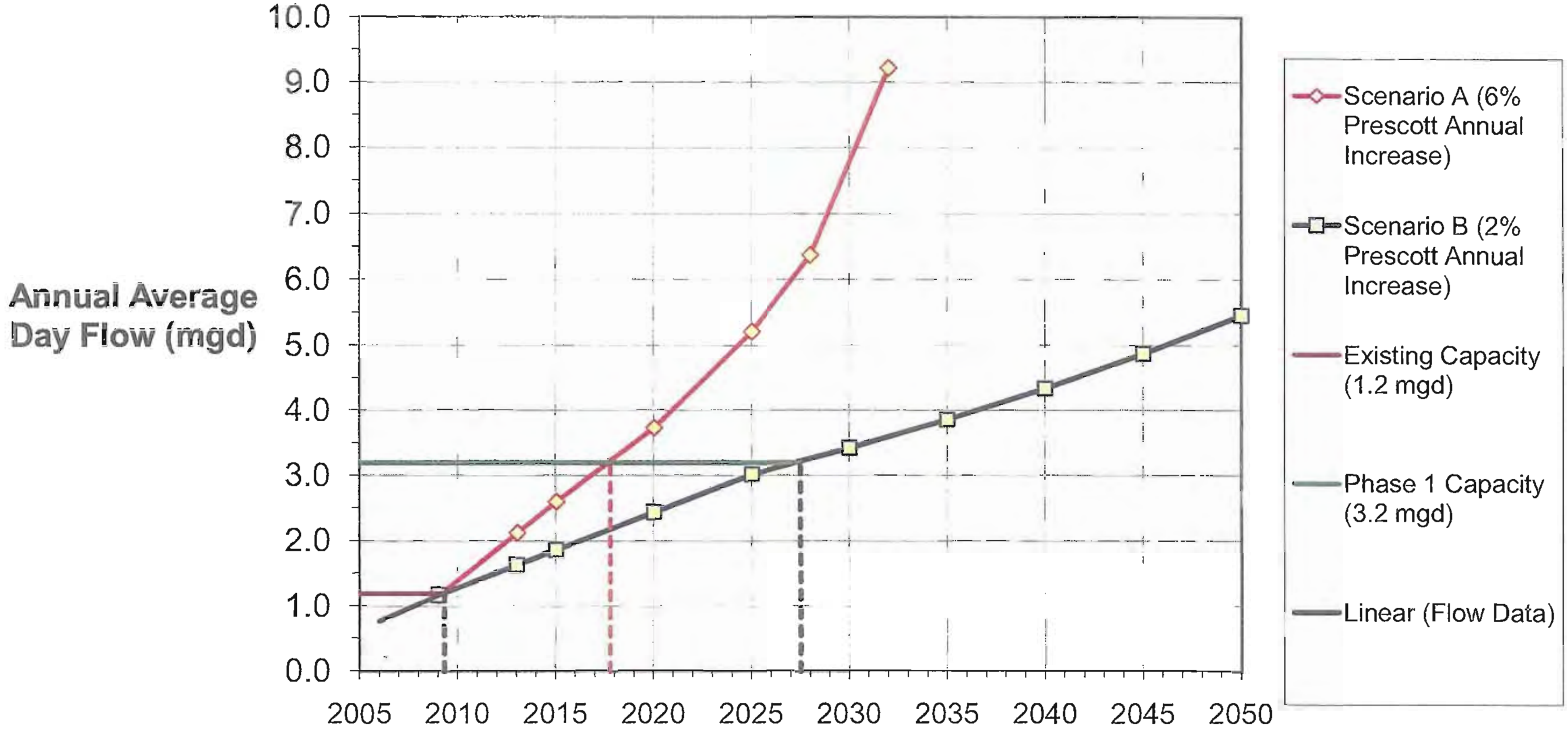
The buildout annual average day flow (AADF) for the Airport WRF tributary area is 5.3 mgd (City of Prescott Wastewater Master Plan). For the purposes of this technology assessment and site master planning project, the buildout capacity was established at 5.4 mgd.

The capacity for each treatment train of the master planned capacity was established at 1.8 mgd (three treatment trains total). This capacity was established based on discussions with the City in several workshops, and it addresses the City's need of having additional treatment capacity beyond the estimated capacity of the existing plant (3.0 mgd) with the upgrades necessary for two treatment trains of 1.8 mgd for a total treatment capacity of 3.6 mgd with the first phase of expansion. This first phase capacity is more cost-effective than a four treatment train alternative, and it also provides a reasonable timeframe before the next capacity expansion is required.

Based on the flow increase scenarios presented in Sections 2.1.1 and 2.1.2 above, Figure 5A.4 shows the expected timing associated with the existing capacity, and with a first phase of improvements to achieve a treatment capacity of 3.6 mgd. It is estimated that the plant will reach its existing capacity between the years 2014 and 2020. It is also estimated that with a Phase 1 capacity of 3.6 mgd, the Sundog WWTP would require the next expansion phase to be in service as early as the Year 2019 and as late as the Year 2034.

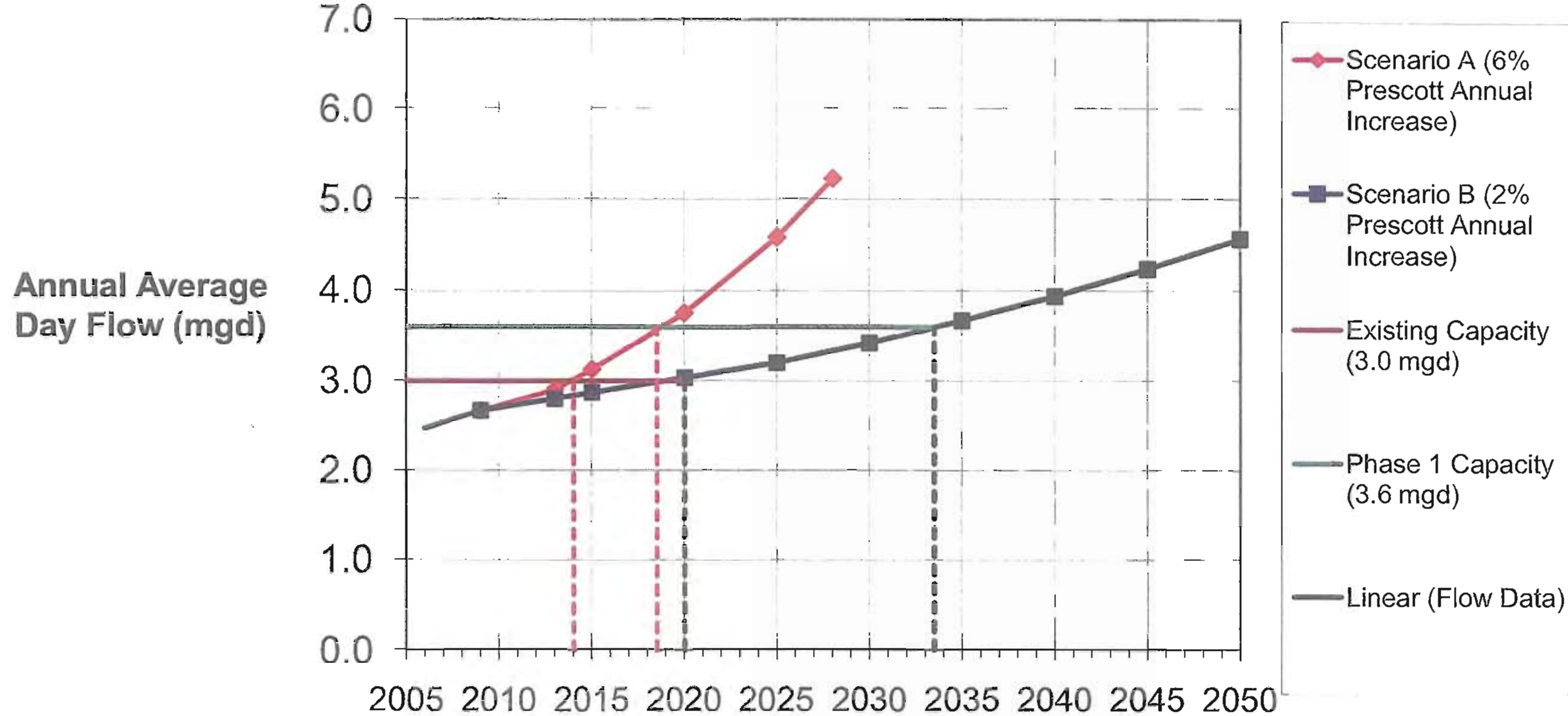
2.2 Design Wastewater Flows

The wastewater flow peaking factors for evaluation of treatment alternatives were developed in TM No. 3A, and are based on historical wastewater quality data between 2006 and 2009 for the Airport WRF. Table 5S.2 presents the design wastewater parameters used for the evaluation of treatment alternatives in this TM No. 5A.



FLOW INCREASE CURVES – AIRPORT WRF

FIGURE 5A.3



FLOW INCREASE CURVES – SUNDOG WWTP

FIGURE 5A.4

Table 5A.2	Design Wastewater Flows and Peaking Factors Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona		
Flow Criteria	**Hydraulic Peaking Factor (1)**	**Buildout Flow (mgd)**	**Phase 1 Flow (mgd)**
Annual Average Day Flow	1.0	9.6	3.2
Maximum Month Average Day	1.4	13.4	4.5
Peak Day	2.0	19.2	6.4
Peak Hour	3.0	28.8	9.6

Note:

(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

2.3 Design Wastewater Loads

The wastewater constituent concentrations used for evaluation of treatment alternatives were developed in TM No. 3A, and are based on historical wastewater quality data between 2006 and 2009 for the Airport WRF. Table 5A.3 presents the design wastewater parameters used for the evaluation of treatment alternatives in this TM No. 5A.

Table 5A.3	Design Wastewater Concentrations Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona		
Parameter	**Unit**	**Annual Average Day**	**Maximum Month Average Day (1)**
Design Concentrations			
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity	mg/L	250	250
Temperature	°C	18.4	12.4
pH	--	7.3	7.3

Note:

(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd). The maximum month flow peaking factor is 1.4.

3.0 ALTERNATIVE TREATMENT TECHNOLOGIES SCREENING

For the initial evaluation of process alternatives, a full range of treatment options were considered for completeness. These process technologies are discussed relative to their potential application to both the Sundog WWTP and the Airport WRF. While common process technologies at each plant were not a requirement of the master plan, there are significant advantages to the City with common or compatible processes. The full range of treatment alternatives were reviewed and discussed in project workshops with the City. There was a project team consensus that two alternatives should be brought forward for detailed evaluation:

- Alternative 1 – conventional activated sludge with Modified Ludzack-Ettinger Process (MLE) for biological nitrification and denitrification
- Alternative 2 – Membrane Bioreactor (MBR) with MLE for biological nitrification and denitrification

The following subsections present the full range of treatment technologies considered, associated benefits and challenges for each and status for detailed consideration.

3.1 Conventional Activated Sludge (MLE)

The Modified Ludzack-Ettinger (MLE) process has an anoxic zone at the head of the aeration basin that receives influent wastewater, return activated sludge, and recycled mixed liquor suspended solids (MLSS) from the end of the aerobic zone. Nitrates produced in the aerobic zone are denitrified in the anoxic zone. The anoxic zone is followed by an aeration zone enabling nitrification and elimination of organic pollutants. Additionally, the MLE process allows for swing zones that provide operational flexibility for nitrogen removal under varying wastewater characteristics. Activated sludge is settled in final clarifiers.

Advantages

- Consistent with existing plant technology.
- Proven technology.
- Simple operation.
- Lower energy than MBR.

Disadvantages

- Requires larger footprint than MBR.
- Requires tertiary filtration to meet Class A+ (compared to MBR).
- Increased disinfection requirements compared to MBR.

Summary

The conventional activated sludge (MLE) process is recommended for detailed evaluation. This process provides proven, reliable nitrogen removal with a stable activated sludge process.

3.2 Four-stage Biological Nutrient Removal (BNR)

The four-stage BNR process comprises an MLE process (anoxic/aerobic zones described above) followed by a post-anoxic and reaeration zone for further removal of nitrates (typically using an external carbon source), and re-aeration to strip any nitrogen gas and aerate the MLSS prior to settling. Activated sludge is settled in final clarifiers.

Advantages

- Potential to achieve lower effluent total inorganic nitrogen (TIN).

Disadvantages

- Additional post-anoxic and reaeration/oxic step.
- Additional nitrogen removal is not needed to meet Class A+ TN limit of 10 mg/L.
- Slightly higher cost than MLE due to additional baffle walls, mixers, and aeration.

Summary

The four-stage BNR process **is not** recommended for detailed evaluation. There is no requirement to achieve additional nitrogen removal beyond the capabilities of an MLE process.

3.3 Extended Aeration Oxidation Ditch

The extended aeration oxidation ditch process typically occurs in a race-track tank that is both mixed and aerated using mechanical rotors. The racetrack provides volume for both aerobic and anoxic conditions to exist, although these are not defined in separate zones or tanks. Therefore, some ditches include external upstream tankage for controlled denitrification in anoxic tanks. Activated sludge is settled in final clarifiers.

Advantages

- Simple operation.
- Stable operation.
- Facility does not require blower complex for aeration.

Disadvantages

- Long hydraulic retention time (typically greater than 20 hours) requires relatively large footprint.
- Relatively high capital cost for tankage.

- Relatively higher operating cost for mechanical aeration and since rotors provide both mixing and aeration, may limit operations flexibility.
- Requires external anoxic basin for MLE process, or relies on simultaneous nitrification and denitrification for nitrate removal.

Summary

The extended aeration oxidation ditch process **is not** recommended for detailed evaluation. It is anticipated that it would be more costly to construct and operate than conventional MLE activated sludge and enhanced stabilization is not required with anaerobic digestion.

3.4 Step Feed Biological Nitrogen Removal

The step feed process is typically constructed in a four-pass aeration basin with influent equally distributed during dry weather to an anoxic zone and following aeration zone in each of the 4 passes. During wet weather flows, the final pass of the aeration tank receives significantly more influent to provide a solids-contact treatment prior to settling and discharge. The process typically produces effluent with higher ammonia concentration than the MLE process due to the short retention time of the final pass for treating 25 percent of influent flows. Activated sludge is settled in final clarifiers.

Advantages

- Smaller aeration basin volume relative to conventional plug flow MLE system.
- No requirement for internal recycle pump.
- Helps to manage wet weather flows.

Disadvantages

- Higher rate process therefore may occasionally struggle to meet total nitrogen alert level of 8 mg/L
- Typically subject to significant surface foam formation.
- Comparable costs to MLE.

Summary

The step feed BNR process **is not** recommended for detailed evaluation. The process is more difficult to control and operate than conventional MLE activated sludge and typically bleeds ammonia in the final effluent due to the step feed process, which could represent a long-term permit issue (future ammonia limit).

3.5 Separate Carbonaceous and Nitrifying Activated Sludge Systems

The two-stage process is typically constructed as a high-rate carbonaceous treatment activated sludge system tankage with clarifiers followed by a separate nitrifying activated sludge system tankage with anoxic zones using carbon addition for denitrification and final clarifiers for sludge settling.

Advantages

- Isolates carbonaceous removal, nitrifying and denitrifying steps to optimize each step independently.

Disadvantages

- Requires a greater number of clarifiers therefore more expensive than MLE.
- Denitrification is typically accomplished with additional of an external carbon source further increasing the complexity and operating costs for this option.

Summary

The two-stage process **is not** recommended for detailed evaluation. The process is more costly to construct and operate than conventional MLE activated sludge and does not utilize available influent carbon for denitrification.

3.6 Membrane Bioreactor in MLE Configuration

The membrane bioreactor (MBR) process in MLE configuration operates very similar to a conventional MLE process, with the key difference that the final clarification step in the conventional MLE process is replaced with membrane filtration. Membrane filtration allows the system to operate at much higher mixed liquor suspended solids concentrations compared to a conventional process, and therefore reduce the required volume of the aeration basins.

The MLE process has an anoxic zone at the head of the aeration basin that receives plant influent and recycled MLSS from the end of the aerobic zone or from the membrane basins. Return activated sludge from the membrane basins may be directed to the aerobic zone to reduce the impact of DO on the anoxic zone. Nitrates produced in the aerobic zone are denitrified in the anoxic zone. The anoxic zone is followed by an aeration zone enabling nitrification and elimination of organic pollutants. Final effluent is filtered from the MLSS using proprietary polymeric membranes producing a filtered final effluent.

Advantages

- Small footprint.
- Stable operation.
- Performance not dependent on sludge settling characteristics.
- Very good effluent quality due to use of microfiltration.

- Does not require final clarifiers or tertiary filters.
- Allows for some forms of future advanced treatment systems for emerging contaminants.

Disadvantages

- Relatively high operating cost.
- Filtration system is sized based on hydraulic capacity of the membrane system. Therefore, for peak wet weather flows equalization is required.
- Membrane replacement is a significant expense that must be annually budgeted and accounted for.
- Instrumentation and control equipment is intensive.
- Without sufficient equalization storage, the plant is susceptible to overflowing in the event of solids overload and plugging of the membrane filtration system.

Summary

The MBR process is recommended for detailed evaluation. The process provides reliable nitrogen removal with stable activated sludge process, and enhances effluent quality with membrane filtration.

3.7 Sequencing Batch Reactors

Sequencing batch reactors (SBR) employ conventional activated sludge processes that operate in “slices of time” in a common tank, rather than in multiple tanks in continuous time. In the continuous inflow variant, influent wastewater flows into the basin continuously regardless of sequence in the cycle. In the true batch system influent is not continuous. Treatment takes place in four steps:

- Step 1: Anoxic period when MLSS is mixed with incoming influent for denitrification of nitrates.
- Step 2: Aeration period during which air is blown into the basin through a diffusion system.
- Step 3: The aerated MLSS settles leaving a clear supernatant on top of the settled sludge.
- Step 4: The supernatant is decanted to the effluent line.

The normal cycle time is approximately 4.8 hours with 0.8 hours anoxic, 2 hours of aeration, 1 hour of settlement, and 1 hour of decanting. SBR plants generally include a storm cycle, which is shorter than the normal treatment cycle.

Advantages

- Does not require separate clarifiers
- Smaller footprint than conventional activated sludge

Disadvantages

- Requires influent or effluent equalization ponds based on non-continuous operation.
- Plant operation is totally dependent on PLC operation
- Technology traditionally limited to small plant capacities (<1 mgd).
- Higher capital cost than MLE, as existing oxidation ditch cannot be used for aeration.

Summary

The SBR process **is not** recommended for detailed evaluation. In this process, it is more difficult to control unwanted nuisance foaming and bulking organisms compared to a conventional MLE activated sludge process, and therefore the SBR process may lead to more effluent total suspended solids excursions particularly during high flows.

3.8 Phased Oxidation Ditch System "BioDenitro™"

The BIO-DENITRO™ process comprises two identical activated sludge tanks and a settling tank. The activated sludge tanks, fitted with aeration and agitation devices, are interconnected and operate either as aerobic or anoxic tanks. Treatment is achieved by switching feed and discharge between the two tanks, in two phases, A and B:

- Phase A, the untreated water is introduced into the first tank operating as an anoxic tank, from where the nitrates accumulated during the previous phase are removed. The mixed liquor passes into the second tank, which operates under aerobic conditions to enable nitrification and elimination of organic pollutants.
- Phase B, the water is admitted to the second tank, and the denitrification and nitrification phases are inverted compared to Phase A.

Advantages

- Simple operation.
- Stable operation.
- Numerous facilities worldwide employ this technology.

Disadvantages

- Large footprint for secondary treatment
- Difficult to plan for redundant operation
- Higher capital cost than MLE

Summary

The phased oxidation ditch process **is not** recommended for detailed evaluation. This process would be more costly to construct and operate than conventional MLE activated sludge and is expensive to include redundant capacity.

3.9 Trickling Filters/Biotowers

Primary effluent is pumped to a trickling filter or biotower and distributed over the media using a hydraulic or mechanical distributor. The wastewater is oxidized by bacteria that grow attached to the fixed media. Most units include a recycle system to maintain a minimum wetting rate for the media. Some systems include a downstream short residence time activated sludge system for coagulation of biological solids. The solids are settled in final clarifiers before discharge. The denitrification process also occurs on fixed media and typically uses supplemental carbon for denitrification.

Advantages

- Low operating cost.
- Attached-growth processes are less susceptible to solids washout.
- Low solids loading to secondary clarifiers.

Disadvantages

- Not suitable for biological nitrogen removal (unreliable for complete nitrification without biofilm using alkaline solutions).
- Downstream denitrification requires supplemental carbon addition.
- Higher capital cost than MLE as existing oxidation ditches cannot be used for aeration.

Summary

Trickling filters or biotowers **are not** recommended for detailed evaluation. The process is estimated to be more costly to construct than conventional MLE activated sludge, and depending on the biofilm and snail control requirements may be more expensive to operate.

3.10 Moving Bed Bioreactors (MBBR) and Denitrification Filters

Additional treatment could be provided downstream of the existing activated sludge process. A moving bed biological reactor (MBBR) could be installed after the secondary clarifiers to completely nitrify residual ammonia followed by subsequent denitrification and suspended solids removal in a denitrification filter. The MBBR process is designed to provide a surface on which to grow biomass for nitrification without loading the mass on the clarifier as is done in conventional activated sludge processes. The media is free-floating in a basin. Diffused aeration provides both the oxygen requirement for nitrification and the mixing requirement to keep media well mixed.

Advantages

- Small footprint technology.
- Attached growth process not susceptible to solids washout.

Disadvantages

- Storage and management of floating media, particularly during basin inspection and repair is problematic.
- Basins require screens to keep media within the tank, the screens require excellent influent screening
- MBBR facilities utilize proprietary media.
- Downstream denitrification requires supplemental carbon addition.
- Higher capital cost than MLE, as existing oxidation ditch cannot be used for aeration.

Summary

The MBBR process **is not** recommended for detailed evaluation. The process is estimated to be more costly to operate than conventional MLE activated sludge due to the need for carbon addition for denitrification.

3.11 Integrated Fixed Film/Activated Sludge Process (IFAS)

Additional treatment could be provided within the existing activated sludge process by installing floating media within dedicated zones of the installed tankage. An IFAS system will assist in completely nitrifying residual ammonia in smaller tankage and denitrification can then be accomplished in larger zones within the existing aeration basins.

The IFAS process is designed to provide a surface on which to grow biomass for nitrification in conjunction with suspended growth biomass. The media is free-floating in a basin. Diffused aeration provides both the oxygen requirement for nitrification and the mixing requirement to keep media well mixed.

Advantages

- Small footprint technology
- Lower solids loading to secondary clarifiers.
- Use of fixed-film biomass reduces chances of loss of biological treatment due to storm flow washout or process upset.

Disadvantages

- Storage and management of floating media, particularly during basin inspection and repair is problematic.
- Basins require screens to keep media within the tank, and the screens require excellent influent screening.

- IFAS facilities utilize proprietary media.
- Additional aeration requirements are needed to properly maintain the free-floating media in suspension

Summary

The IFAS process **is not** recommended for detailed evaluation. It is more difficult to maintain than conventional MLE activated sludge due to the need for media, screens, as well as additional aeration and influent screening requirements.

3.12 Biological Aerated Filters – Nitrification and Denitrification

Multiple vendor market versions of biological aerated and denitrifying filters (BAFs) are used for wastewater treatment. BAFs are used for both BOD and TSS removal, as well as for nitrification and denitrification. The technology is proven at both small scale and large scale. Two companies (Kruger, owned by Veolia Water, and Infilco Degremont, owned by Suez) have supplied the majority of systems currently operating. Kruger supplies the BioStyr™ process. Infilco Degremont supplies the BioFor™ process.

BAFs could be used to nitrify the waste stream from the primary clarifiers. The nitrifying BAF effluent could then be denitrified in a denitrifying BAF. Influent flow is pumped to a common channel where flow is hydraulically split to the operating nitrifying BAF. BAFs are individually controlled through automatic gates and valves. The BAF backwash process including air scour is fully automated. The backwash is directed to the primary clarifiers for co-settling with primary solids. No separate backwash tank is required.

Advantages

- Applicable for tertiary nitrification
- Less proven than denitrification filters for producing low effluent TSS.

Disadvantages

- Potential for clogging with large debris
- Subject to surfactant foaming
- Proprietary vendor system
- Higher capital cost than MLE, as existing oxidation ditch cannot be used for aeration.

Summary

Biological aerated filters **are not** recommended for detailed evaluation. These filters are estimated to be MORE costly to construct and operate than conventional MLE activated sludge.

4.0 ALTERNATIVE 1 – CONVENTIONAL MLE

Based on the liquid treatment technologies screening process presented in Section 0, the Conventional (MLE) Treatment Alternative was brought forward for detailed evaluation. The alternative evaluation was based on identifying the facilities required at buildout (9.6 mgd) as well as Phase 1 (3.2 mgd). The detailed evaluation process included the following steps:

- Conceptual process design to determine facilities required.
- Process unit sizing and evaluation of treatment performance using process modeling.
- Development of preliminary site layouts.
- Development of planning-level cost estimates for capital and operations and maintenance costs.
- Comparison of alternatives based on economic and non-economic factors (Sections 6.1 and 6.2).

4.1 Process Design Criteria

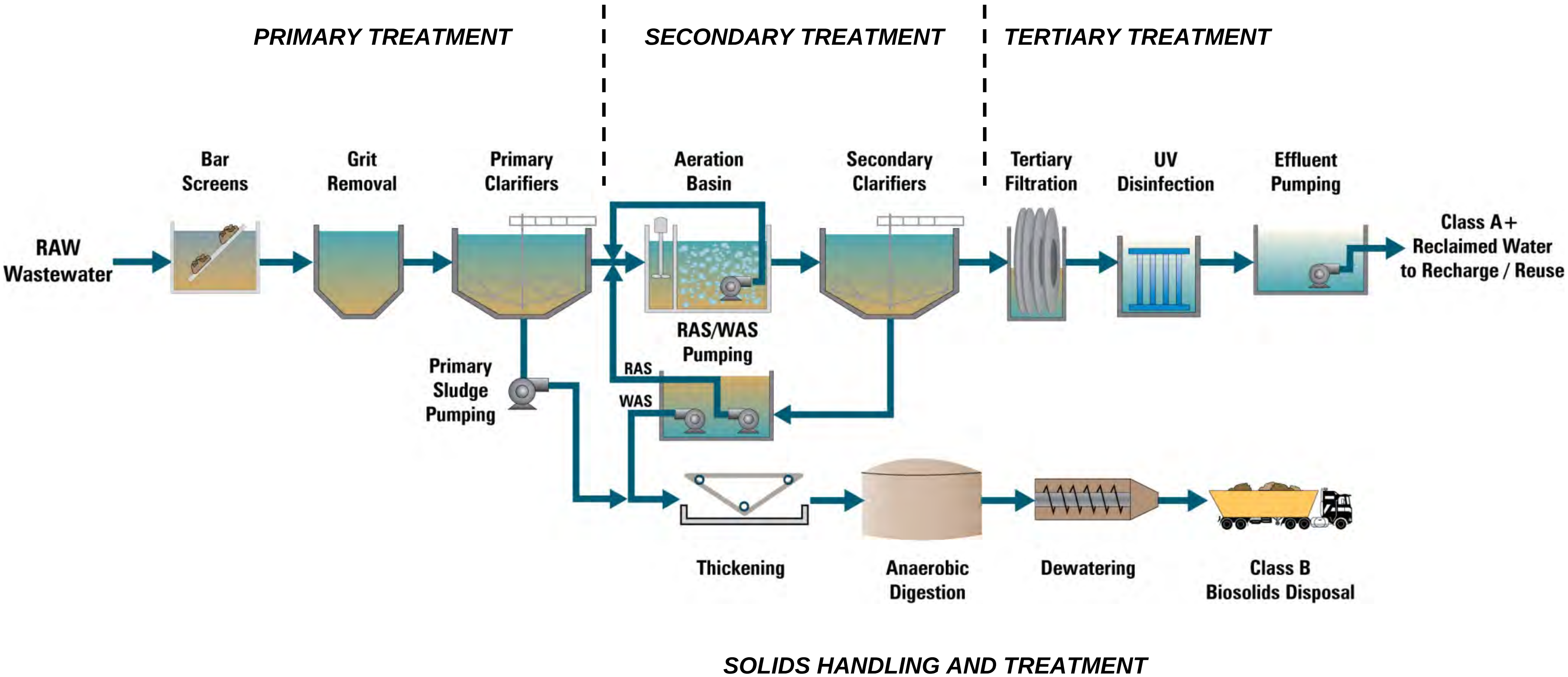
The processes for liquids and solids treatment for the conventional treatment alternative are described below. The general approach for the conceptual process design was to base the unit process sizing on the requirements for buildout, incorporating as many of the existing facilities as possible into the first phase of the master planned facilities. The process flow schematic for the conventional treatment alternative is shown in Figure 5A.5.

4.1.1 Preliminary Treatment

Screening was based on the addition of new, in-channel mechanical bar screens (step screens) including a bypass with a manual screen. The sizing criteria for the screens is based on the wastewater velocity through the bar openings, which is determined by the width of the channel and the operating side water depth inside the channel. As the plant influent flow increases towards buildout, the operating side water depth in the channels can be increased to allow using the same screen units and channels from Phase 1 to buildout. The screen sizing criteria was based on this approach. Utilization of the existing screen beyond its rated capacity of 2.4 mgd is not feasible due to the channel depth and existing hydraulics.

For costing and site layout purposes, grit removal was based on the assumption of mechanical vortex units in concrete basins, a common approach in municipal treatment plants, which is consistent with the existing technology used at the City's facilities. It should be noted that a detailed evaluation of both screening and grit removal technologies should be part of a preliminary design effort.

The number of screening and grit removal units assumed at Phase 1 and buildout are summarized in Table 5A.4.



CONVENTIONAL (MLE) ACTIVATED SLUDGE PROCESS FLOW SCHEMATIC

FIGURE 5A.5

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Table 5A.4 Conventional (MLE) Treatment Alternative Facilities Summary
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Unit Process	Facilities Required at Phase 1 (3.2 mgd)	Facilities Required at Buildout (9.6 mgd)
Coarse Screening	• 1 mechanical bar screen (duty) • 1 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control.	• 2 mechanical bar screens (duty) • 2 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control.
Grit Removal	• 1 mechanical vortex unit, concrete basins	• 2 mechanical vortex units, concrete basins
Primary Sedimentation	N.A.	• 3 units, 80-ft diameter with dome covers and clarifier mechanism
Primary Sludge Pump Station	N.A.	• Pump station structure • Progressive Cavity Pumps: 2 duty + 1 standby, 100 gpm each • Primary scum pumps: 2 units, 160 gpm each
Activated Sludge Treatment Basins	• 2 trains, 3.1 MG per train (6.2 MG total) • Submersible mixers (20 HP), 2 per train • Fine bubble diffuser system • Mixed liquor return pumps: 7,800 gpm/basin	• 3 trains, 3.1 MG per train (9.2 MG total) • Submersible mixers (20 HP), 2 per train • Fine bubble diffuser system • Mixed liquor return pumps, 15,500 gpm/train
Blower Building	• Centrifugal blowers • 3 units (one redundant), 3,500 scfm each • Blower building (1,200 sf)	• Centrifugal blowers • 5 units (one redundant), 3,500 scfm each • Blower building (1,800 sf)
Secondary Sedimentation	• 2 units (one redundant at AADF loads) • 100-ft diameter, 15-ft side water depth	• 4 units (one redundant at AADF loads) • 100-ft diameter, 15-ft side water depth

Table 5A.4 Conventional (MLE) Treatment Alternative Facilities Summary
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Unit Process	Facilities Required at Phase 1 (3.2 mgd)	Facilities Required at Buildout (9.6 mgd)
RAS/WAS Pumping	• Wet well with submersible centrifugal pumps. • RAS: 2 pumps (one redundant); 2,800 gpm each • WAS: 2 units (one redundant); 500 gpm each • Secondary scum pumps, 2 pumps	• Wet well with submersible centrifugal pumps. • RAS: 4 pumps (one redundant); 2,800 gpm each • WAS: 3 units (one redundant); 500 gpm each • Secondary scum pumps, 4 pumps
Tertiary Filtration	• Cloth media disk filters in concrete basins. • 3 units (one redundant), total filtration area: 1,938 sf	• Cloth media disk filters in concrete basins. • 6 units (one redundant), total filtration area: 3,876 sf
Disinfection	• UV disinfection, open channel low-pressure high-output. • 1 channel, 4 banks in channel (one redundant bank in channel).	• UV disinfection, open channel low-pressure high-output. • 3 channels, 4 banks per channel (one redundant bank per channel).
Effluent Pumping	• Wet well volume; 25,000 cf • 2 vertical turbine pumps (one redundant); 5,000 gpm each	• Wet well volume; 25,000 cf • 5 vertical turbine pumps (one redundant); 5,000 gpm each
Solids Handling	• One additional centrifuge (80 to 120 gpm capacity) in existing building.	• 3 thickening units (one redundant); 500 gpm • 3 dewatering units (one redundant); 200 gpm • Solids handling building (16,991 sf)
Digestion	N.A.	• 4 digesters, 85 ft diameter, 25 ft SDW. • Boiler building, flares, mixing system

4.1.2 Primary Treatment

Primary treatment reduces mainly BOD and TSS from the plant influent loadings. Primary treatment was incorporated as part of the process design in order to reduce the aeration basin volume and process air required for secondary treatment. Circular clarifiers and a primary sludge pump station were assumed for costing and site layout purposes.

Primary treatment was not included for Phase 1 conditions. Primary clarification produces unstabilized primary sludge, and the Airport WRF facilities do not currently have sludge stabilization facilities (i.e., digesters). Therefore, it was assumed that primary treatment would be constructed together with digestion facilities at Phase 2 at the earliest for cost effectiveness.

The size and number of primary clarifier units at Phase 1 and buildout are summarized in Table 5A.. Detailed process calculations with sizing criteria such as surface overflow rate, BOD and TSS removal efficiencies are included in Appendix A.

4.1.3 Secondary Treatment

The MLE activated sludge treatment process includes compartmentalized aeration basins with two anoxic zones, one swing zone and three aeration zones, arranged in a two-pass configuration. Swing zones (equipped with mixers and aeration diffusers) provide the flexibility to adjust the relative anoxic and aeration volumes to changes in the wastewater characteristics. Low-head mixed liquor return pumps provide the recycle of nitrates from the last aeration zone back to the first anoxic zone. Submersible mixers were assumed for mixing in the anoxic zones. Membrane disc, fine bubble diffusers were assumed in order to provide efficient aeration and minimize the required blower size.

Centrifugal blowers in a dedicated building were assumed for costing and site layout purposes. The blower building was assumed to expand from Phase 1 to build out in order to minimize footprint and cost for Phase 1.

Circular secondary clarifiers provide solids-liquid separation of the mixed liquor suspended solids from the aeration basins. The larger clarifier size required for Phase 1 and buildout as compared to the existing secondary clarifier (100 ft versus 60 ft), and the site layout prevented reutilization of the existing clarifier for final clarification (see solids handling for reutilization of existing secondary clarifier).

A new return activated sludge (RAS) and waste activated sludge (WAS) pump station was assumed for Phase 1 and buildout. For costing and layout purposes, the pump station was assumed to have a wet well with submersible pumps. The wet well was assumed to be constructed in Phase 1, with additional pumps to provide sufficient capacity for buildout.

The design criteria for the aeration basins, blower building, and secondary clarifiers at Phase 1 and buildout are summarized in Table 5A.. Detailed process calculations with sizing criteria such as mixed liquor suspended solids, solids retention time, surface overflow rates, clarifier safety factors, process air requirements, RAS and WAS flows are included in Appendix A.

4.1.4 Tertiary Treatment

Based on the evaluation and recommendations presented in TM No. 7 - Tertiary Filtration Evaluation, the liquid treatment alternatives analyzed in this TM No. 5A assume disc filter technology. The disc filters considered would require new basins, and due to site layout considerations reusing the existing traveling bridge filter structure was not considered.

For disinfection, evaluation of alternatives under this TM No. 5A are based on UV disinfection technology. UV is the existing technology used at both the Airport WRF and the Sundog WWTP. In-channel UV technology was assumed for this evaluation based on other experiences with conventional MLE projects.

Other disinfection alternatives are available to the City, such as chlorine and ozone disinfection. A detailed evaluation of disinfection technologies is a preliminary design task that should consider factors such as capital and operational costs, disinfection by-product formation, reliability, redundancy, among others. The detailed evaluation of disinfection technologies is not included in the current project, but should be performed as part of the facilities design.

For the purposes of this master plan, UV disinfection was consistently used for the evaluation of treatment alternatives and planning level costs. This approach was selected to provide conservative cost estimates, which are appropriate for budgeting purposes.

The design criteria for the tertiary filters and disinfection at Phase 1 and buildout are summarized in Table 5A.. Detailed process calculations with sizing criteria such as hydraulic loading rates, number of units, and filtration area are included in Appendix A.

4.1.5 Effluent Pumping

For the purposes of this study, vertical turbine pumps in a wet well were assumed. The wet well was assumed to be constructed in Phase 1, with additional pumps to provide sufficient capacity for buildout. The design criteria for the effluent pump station are summarized in Table 5A..

4.1.6 Solids Handling and Stabilization

Anaerobic digestion to achieve Class B biosolids quality was assumed as the sludge stabilization process for the conventional MLE process alternative. Aerobic digestion was not considered for the MLE process due to the additional aeration requirements that would result from aerobically digesting primary sludge.

Anaerobic digestion was not considered for Phase 1 due to the relatively large capital costs associated with digestion facilities. Therefore, landfill disposal of unstabilized dewatered sludge is assumed for Phase 1 at the Airport WRF.

Solids thickening was assumed upstream of the anaerobic digestion process, in order to reduce the volume of solids and therefore the tankage required for the digestion process. For the purposes of this evaluation, gravity belt thickeners were assumed based on current practice at the Sundog WWTP.

Solids dewatering was assumed downstream of the anaerobic digestion process, in order to reduce the volume of solids for disposal. For the purposes of this evaluation, centrifuge dewatering was assumed based on current practice at the Airport WRF. For Phase 1, it was assumed that additional dewatering equipment will be installed in the existing building. It was also assumed that the existing secondary clarifier was used to pre-thicken solids before they are sent to the dewatering centrifuges, in order to avoid overloading the centrifuges.

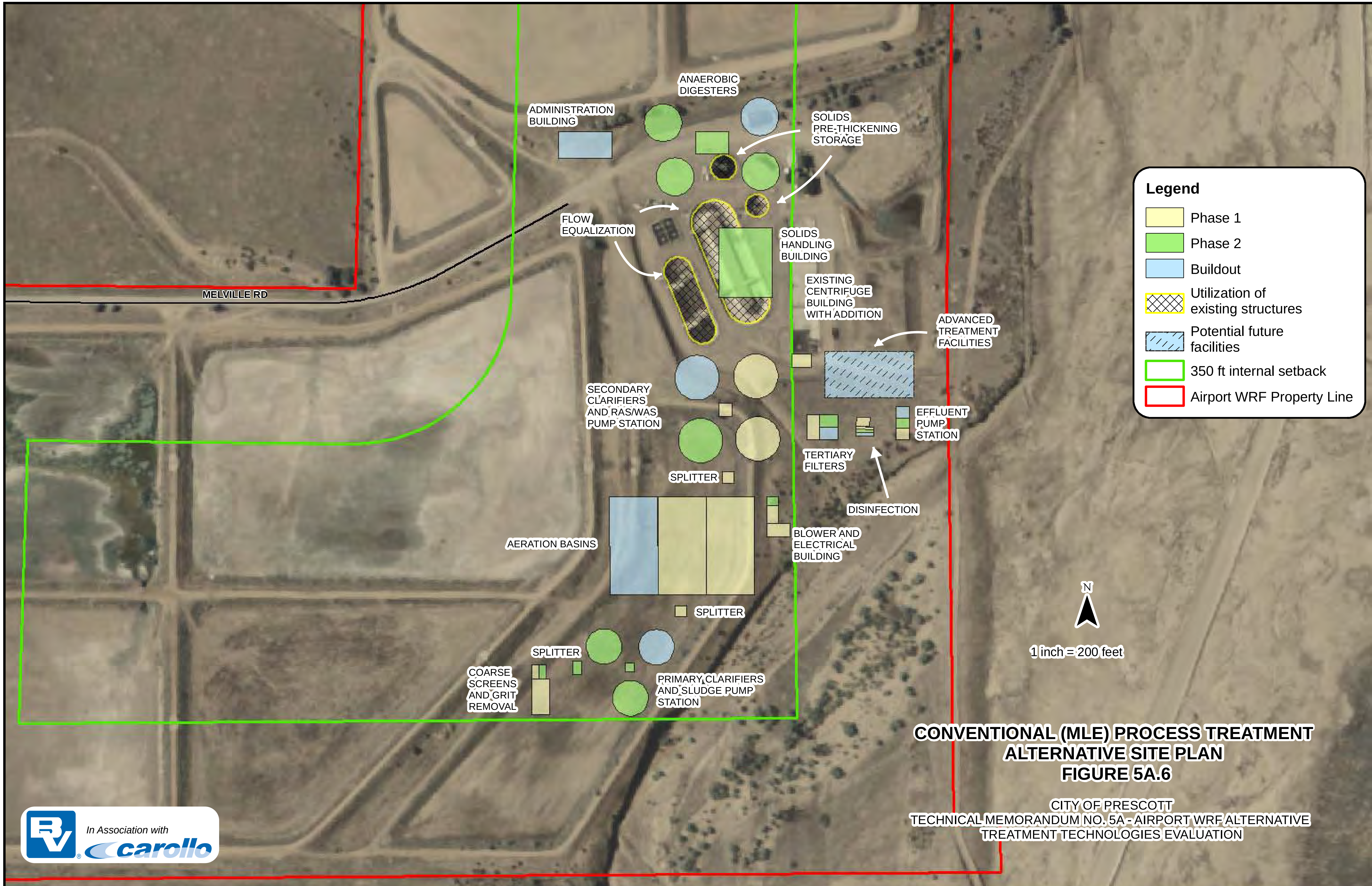
As mentioned for other unit processes, a detailed evaluation of the different solids handling technologies available to the City (rotary drum thickeners, belt filter press, centrifuges, etc.) is a preliminary design task that should determine the thickening and dewatering technologies for the actual design for the facilities, but is not included as part of this project.

4.1.7 Design Criteria Summary

Table 5A. summarizes the required facilities for the conventional treatment alternative at a buildout flow of 9.6 mgd, and a Phase 1 flow of 3.2 mgd. Also listed in Table 5A. are the assumptions on the type of equipment or process that were made for the purposes of costing and layout. It should be noted that selection of specific equipment types or process alternatives should be further evaluated during preliminary design. A process model output summary is included in Appendix A with specific design criteria for each of the unit processes, including operating parameters and expected effluent quality.

4.2 Site Plan

Figure 5A.6 presents the preliminary site plan for the conventional treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown within the 350-feet internal setback from the property boundary. The layout assumes that the footprint occupied by the effluent recharge basin in the southeast end of the site is used for the required treatment facilities. Another assumption is that the footprint currently occupied by the older oxidation ditch and the existing secondary clarifiers is reclaimed for the solids treatment and handling facilities.



CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE SITE PLAN
FIGURE 5A.6

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5.0 MEMBRANE TREATMENT ALTERNATIVE

Based on the liquid treatment technologies screening process presented in Section 0, the Membrane Bioreactor (MBR) Treatment Alternative was brought forward for detailed evaluation. The alternative evaluation was based on identifying the facilities required at buildout (9.6 mgd) as well as Phase 1 (3.2 mgd). The detailed evaluation process included the following steps:

- Conceptual process design to determine facilities required.
- Process unit sizing and evaluation of treatment performance using process modeling.
- Development of preliminary site layouts.
- Development of planning-level cost estimates for capital and operations and maintenance costs.
- Comparison of alternatives based on economic and non-economic factors (Sections 6.1 and 6.2).

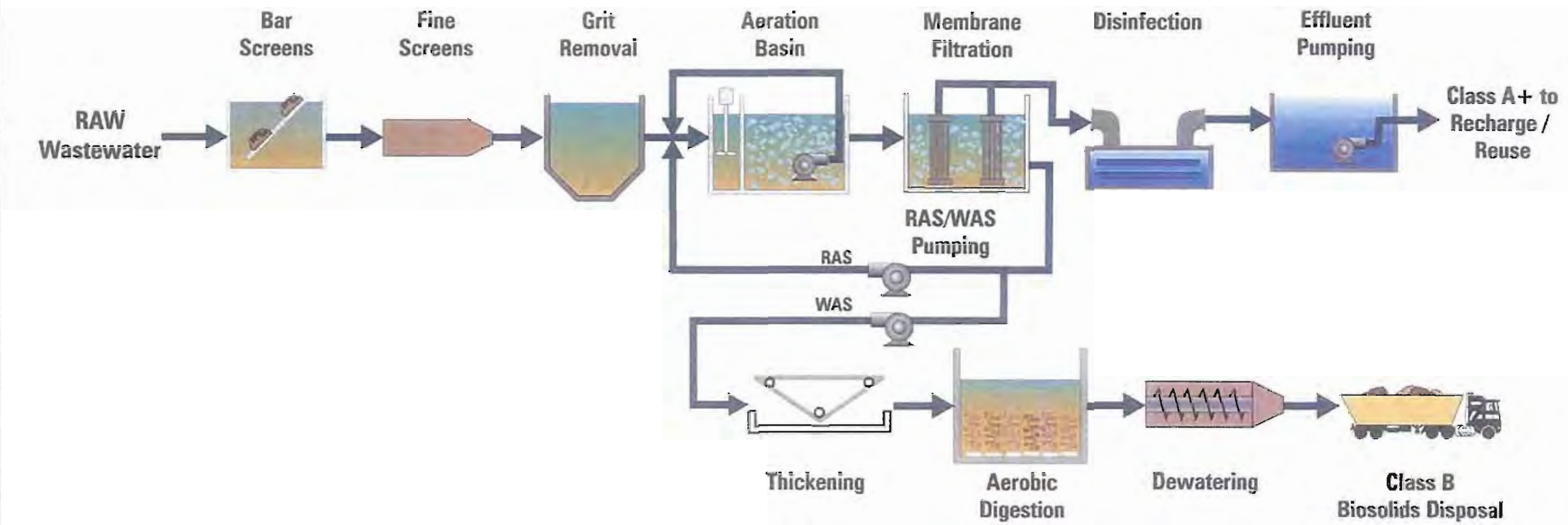
5.1 Process Design Criteria

The processes for liquids and solids treatment for the conventional treatment alternative are described below. The general approach for the conceptual process design was to base the unit process sizing on the requirements for buildout, incorporating as many of the existing facilities as possible into the first phase of the master planned facilities. The process flow schematic for the MBR treatment alternative is shown in Figure 5A.7.

5.1.1 Preliminary Treatment

Two-stage screening (coarse and fine) screening was assumed for this alternative. Coarse screening was based on the addition new, in-channel mechanical bar screens (step screens) including a bypass with a manual screen. The sizing criteria for the screens is based on the wastewater velocity through the bar openings, which is determined by the width of the channel and the operating water depth. As the plant influent flow increases towards buildout, the operating depth in the channels can be increased to allow using the same screen units from Phase 1 to buildout. The screen sizing criteria was based on this approach. Utilization of the existing screen beyond its rated capacity of 2.4 mgd is not feasible due to the channel depth and existing hydraulics.

Fine screening was based on the addition of rotary drum screens with perforated plate openings, a common type of fine screens required for membrane treatment facilities. MBRs have specific fine screening requirements in order to protect the membranes. A fully redundant unit was assumed.



MEMBRANE BIOREACTOR PROCESS FLOW SCHEMATIC

FIGURE 5A.7

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For costing and site layout purposes, grit removal was based on the assumption of mechanical vortex units in concrete basins, a common approach in municipal treatment plants, which is consistent with the existing technology used at the City's facilities. It should be noted that a detailed evaluation of both coarse and fine screening and grit removal technologies should be part of a preliminary design effort.

The number of screening and grit removal units assumed at Phase 1 and buildout are summarized in Table 5A.5.

5.1.2 Primary Treatment

Primary treatment was not included for the MBR process treatment alternative. Primary treatment reduces mainly BOD and TSS from the plant influent loadings. Primary treatment was not incorporated as part of the process design because the relatively small reduction in aeration basin volume compared to the addition of primary clarifiers and anaerobic digestion facilities to stabilize the primary sludge.

5.1.3 Secondary Treatment

The activated sludge treatment process is based on an MLE configuration, and includes compartmentalized aeration basins with two anoxic zones, one swing zone and three aeration zones, arranged in a single-pass configuration. Swing zones (equipped with mixers and aeration diffusers) provide the flexibility to adjust the relative anoxic and aeration volumes to changes in the wastewater characteristics. Submersible mixers were assumed for mixing in the anoxic zones. Membrane disc, fine bubble diffusers were assumed in order to provide efficient aeration and minimize the required blower size.

Centrifugal blowers in a dedicated building were assumed for costing and site layout purposes. The blower building was assumed to expand from Phase 1 to build out in order to minimize footprint and cost for Phase 1.

The membrane trains replace the function of secondary clarifiers and tertiary filtration in a conventional wastewater treatment process. Hollow fiber membrane technology was assumed for this evaluation. Some of the elements of the membrane separation process include the membrane tanks, membrane modules, permeate pumps, air scour blowers, chemical cleaning system, among others. Return activated sludge (RAS) and waste activated sludge (WAS) pumping was assumed to be from the membrane tanks. A membrane building was assumed to include the membrane-related equipment as well as the disinfection units (see Section 5.1.4 for disinfection). It was assumed that the building would be constructed under Phase 1, and additional equipment would then be added with subsequent phases.

Table 5A.5 Membrane (MBR) Treatment Alternative Facilities Summary
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Unit Process	Facilities Required at Phase 1 (3.2 mgd)	Facilities Required at Buildout (9.6 mgd)
Coarse Screening	• 1 mechanical bar screen (duty) • 1 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control	• 2 mechanical bar screens (duty) • 2 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control
Grit Removal	• 1 mechanical vortex unit, concrete basins	• 2 mechanical vortex units, concrete basins
Fine Screening	• 2 Rotary drum screen units (1 duty + 1 standby) • 1 mechanical vortex unit in concrete basin • Building (5,720 sf)	• 3 Rotary drum screen units (2 duty + 1 standby) • 2 mechanical vortex units in concrete basins • Building (5,720 sf)
Activated Sludge Treatment Basins	• 2 trains, 1.2 MG per train (2.4 MG total) • Submersible mixers (10 HP), 2 per train • Fine bubble diffuser system	• 6 trains, 1.2 MG per train (7.2 MG total) • Submersible mixers (10 HP), 2 per train • Fine bubble diffuser system
Blower Building	• Centrifugal blowers • 3 units (one redundant), 6,000 scfm each • Blower building (1,200 sf)	• Centrifugal blowers • 5 units (one redundant), 6,000 scfm each • Blower building (1,800 sf)
Membrane Filtration	• Membrane system trains, 2 duty + 1 redundant • Chemical cleaning system • Air scour blowers (3 duty + 1 standby) • RAS and WAS pumps	• Membrane system trains, 6 duty + 1 redundant • Chemical cleaning system • Air scour blowers (7 duty + 1 standby) • RAS and WAS pumps
Disinfection	• UV disinfection, closed vessel low-pressure high-output. • 3 reactors (one redundant).	• UV disinfection, closed vessel low-pressure high-output. • 7 reactors (two redundant).

Table 5A.5 Membrane (MBR) Treatment Alternative Facilities Summary
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Unit Process	Facilities Required at Phase 1 (3.2 mgd)	Facilities Required at Buildout (9.6 mgd)
Effluent Pumping	• Wet well volume; 25,000 cf • 2 vertical turbine pumps (one redundant); 5,000 gpm each	• Wet well volume; 25,000 cf • 5 vertical turbine pumps (one redundant); 5,000 gpm each
Solids Handling	• One additional centrifuge (80 to 120 gpm) in existing building.	• 3 thickening units (one redundant); 500 gpm • 3 dewatering units (one redundant); 200 gpm • Solids handling building (16,991 sf)
Digestion	• Use existing oxidation ditch (newer) as digester • 2 blower units	• Operation of newer oxidation ditch as digester • 6 digesters, 85 ft square 20 ft SDW • 6 blowers and fine bubble diffuser system • Blower building (7,225 sf)

Sizing of the membrane filtration facilities was based on providing membrane capacity to treat up to peak day flows with one membrane train out of service. Additional freeboard in the aeration basins (4 feet of working side water depth) was considered for equalization of peak hour flows. Equalization volume could also be provided in a separate tank. The cost-effectiveness and operational advantages and disadvantages of these alternatives need to be further evaluated during preliminary design. For the purposes of this master plan, additional freeboard in the aeration basins was considered for equalization of peak hour flows.

The design criteria for the aeration basins, blower building, and membrane filtration at Phase 1 and buildout are summarized in Table 5A.. Detailed process calculations with sizing criteria such as mixed liquor suspended solids, solids retention time, flux rates, process air requirements, RAS and WAS flows are included in Appendix A.

5.1.4 Tertiary Treatment

Additional tertiary filtration beyond membrane filtration is not required for the MBR treatment process.

For disinfection, evaluation of alternatives under this TM No. 5A are based on UV disinfection technology. UV is the existing technology used at both the Airport WRF and the Sundog WWTP. In-vessel UV technology was assumed for this evaluation based on other experiences with MBR projects.

Other disinfection alternatives are available to the City, such as chlorine and ozone disinfection. A detailed evaluation of disinfection technologies is a preliminary design task that should consider factors such as capital and operational costs, disinfection by-product formation, reliability, redundancy, among others. The detailed evaluation of disinfection technologies is not included in the current project, but should be performed as part of the facilities design.

For the purposes of this master plan, UV disinfection was consistently used for the evaluation of treatment alternatives and planning level costs. This approach was selected to provide conservative cost estimates, which are appropriate for budgeting purposes.

The design criteria for the tertiary filters and disinfection at Phase 1 and buildout are summarized in Table 5A.5.

5.1.5 Effluent Pumping

For the purposes of this study, vertical turbine pumps in a wet well were assumed. The wet well was assumed to be constructed in Phase 1, with additional pumps to provide sufficient capacity for buildout. The design criteria for the effluent pump station are summarized in Table 5A.4.

5.1.6 Solids Handling and Stabilization

Aerobic digestion to achieve Class B biosolids quality was assumed as the sludge stabilization process for the conventional MLE process alternative. Digestion was not considered for Phase 1 due to the relatively large capital costs associated with digestion facilities to meet Class B quality biosolids. Therefore, landfill disposal of unstabilized dewatered sludge is assumed for Phase 1 at the Airport WRF.

Solids thickening was assumed upstream of the aerobic digestion process, in order to reduce the volume of solids and therefore the tankage required for the digestion process. For the purposes of this evaluation, gravity belt thickeners were assumed based on current practice at the Sundog WWTP.

Solids dewatering was assumed downstream of the aerobic digestion process, in order to reduce the volume of solids for disposal. For the purposes of this evaluation, centrifuge dewatering was assumed based on current practice at the Airport WRF. For Phase 1, it was assumed that additional dewatering equipment will be installed in the existing building. It was also assumed that the existing secondary clarifier was used to pre-thicken solids before they are sent to the dewatering centrifuges, in order to avoid overloading the centrifuges.

As mentioned for other unit processes, a detailed evaluation of the different solids handling technologies available to the City (rotary drum thickeners, belt filter press, centrifuges, etc.) is a preliminary design task that should determine the thickening and dewatering technologies for the actual design for the facilities, but is not included as part of this project.

5.1.7 Design Criteria Summary

Table 5A. summarizes the required facilities for the membrane treatment alternative at a buildout flow of 9.6 mgd, and a Phase 1 flow of 3.2 mgd. Also listed in Table 5A. are the assumptions on the type of equipment or process that were made for the purposes of costing and layout. It should be noted that selection of specific equipment types or process alternatives should be further evaluated during preliminary design. A process model output summary is included in Appendix A with specific design criteria for each of the unit processes, including operating parameters and expected effluent quality.

5.2 Site Plan

Figure 5A.8 presents the preliminary site plan for the membrane treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown within the 350-feet internal setback from the property boundary. The layout assumes that the footprint occupied by the effluent recharge basin in the southeast end of the site is used for the required treatment facilities. Another assumption is that the footprint currently occupied by the older oxidation ditch and the existing secondary clarifiers is reclaimed for the solids treatment facilities at buildout.

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6.0 ALTERNATIVES COMPARISON

The alternatives detailed evaluation is summarized in this section, and includes both economic and non-economic comparisons of the conventional treatment process and the membrane bioreactor treatment process alternatives.

6.1 Cost Comparison

An economic comparison of the two treatment alternatives for buildout conditions is presented in Table 5A.6. A more detailed breakdown of capital and operational and maintenance costs is included in Appendix B. The economic comparison of the two treatment alternatives is based on total life-cycle costs, and include capital costs as well as and the present worth cost of the annual operational and maintenance costs over a period of 20 years.

The capital cost of the MBR treatment alternative is approximately 2 percent higher than the conventional treatment alternative. The life-cycle costs of the MBR alternative is approximately 11 percent higher, which corresponds to a higher annual operations and maintenance cost. The conventional treatment alternative represents the lowest-cost option between the two alternatives evaluated.

Table 5A.6 Treatment Alternatives Economic Comparison for Buildout (9.6 mgd)
Technical Memorandum No. 5A - Alternatives Evaluation
City of Prescott, Arizona

Criteria	Conventional (MLE) Treatment Alternative	Membrane (MBR) Treatment Alternative
Estimated Construction Cost	$121,864,000	$124,512,000
Annual Operations and Maintenance Costs	$3,631,000	$4,860,000
Total Life-Cycle Cost (1)	$171,744,000	$191,282,000

Note:
(1) As present value, assuming life-cycle period of 20 years, interest rate of 6 percent, and escalation rate of 2 percent.

A capital cost comparison of the two treatment alternatives for Phase 1 conditions (3.2 mgd) is presented in Table 5A.7. A more detailed breakdown of capital costs is included in Appendix B. The MBR alternative represents almost a 60 percent higher capital cost compared to the conventional (MLE) treatment alternative. These Phase 1 capital costs demonstrate that conventional (MLE) treatment is lowest-cost option between the two alternatives evaluated.

Table 5A.7	Treatment Alternatives Economic Comparison for Phase 1 (3.2 mgd) Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona	
Criteria	**Conventional (MLE) Treatment Alternative**	**Membrane (MBR) Treatment Alternative**
Estimated Construction Cost	$30,416,000	$48,272,000

6.2 Non Economic Evaluation

The technology evaluation process also considered non-economic factors. These factors are subjective but may have a significant impact on the applicability of a technology. The non-economic factors identified for the process selection were present worth, consistency with existing plant processes, process complexity, reliance on automation, effluent quality, foot print and process stability. Table 5A.8 shows a relative comparison of the treatment technologies with a score basis of 1 through 10 (higher value corresponding to more desirable). A multiplier was also applied to each of the non-economic factors to properly weigh those factors most important to the City. The treatment technology with the highest overall total score is the most attractive process based on a comparison of these non-economic factors.

Table 5A.8	Treatment Alternatives Non-Economic Comparison Technical Memorandum No. 5A - Alternatives Evaluation City of Prescott, Arizona				
		Alternative 1 – Conventional MLE		**Alternative 2 – MBR**	
Criteria	**Weighing Factor**	**Raw Score**	**Weighted Score**	**Raw Score**	**Weighted Score**
Consistency with Existing Plant Process	x 2	8	16	4	8
Process Complexity	x 3	8	24	4	12
Reliance on Automation	x 2	8	16	4	8
Effluent Quality	x 3	6	18	10	30
Foot Print	x 2	6	12	8	16
Process Stability	x 3	6	18	8	24
Instrumentation and Controls Intensity	x 3	8	24	4	12
Compatibility with Advanced Treatment Processes	x 2	5	10	8	16
Sustainability and Reuse	x 3	6	18	8	24
TOTAL OVERALL SCORE	-	-	**156**	**-**	**150**

<u>Note</u>:
(1) Comparison of non-economic factors where 10 = best and 1 = worst

7.0 LIQUID SECONDARY TREATMENT RECOMMENDATION

The economic evaluation presented in Section 6.1 shows that the capital costs of the conventional (MLE) process and the MBR process alternatives are practically the same given the accuracy of the cost estimates prepared for this effort. However, the conventional (MLE) process alternative has the lowest total life cycle costs, including operation and maintenance costs. The conventional (MLE) process also has a significantly lower Phase 1 capital cost compared to the MBR process alternative.

The non-economic evaluation presented in Section 6.2 shows that the conventional (MLE) process alternative had a higher score (better) than the MBR process alternative when considering non-economic factors.

Based on the results of the economic and non-economic evaluation, and discussions with City staff on project workshops, the recommended liquid secondary treatment technology for the Airport WRF is the conventional (MLE) activated sludge process.

It should be noted that a conventional MLE process is compatible with advanced treatment processes. Advanced treatment can be achieved by the addition of process units downstream of the MLE treatment process, such as membrane filtration and advanced oxidation processes. This flexibility allows the City to pursue advanced treatment in the future, depending on future requirements and regulations.

APPENDIX A

PROCESS MODEL CALCULATIONS

CAROLLO ENGINEERS, PC	
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PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE
Calc by CL	Date Time 06/29/2010 9:42 AM Chk by/Date

Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
SUMMARY:								
FLOW RATES, mgd:								
- Raw WW Flow	3.2	4.5	9.6	13.4	3.2	4.5	9.6	13.4
- Flow to Primaries	3.4	4.7	10.0	14.2	3.3	4.6	9.9	13.9
- Influent Flow to Activated Sludge	3.4	4.7	10.0	14.0	3.3	4.6	9.9	14.0
INFLUENT WASTEWATER QUALITY, mg/L:								
- BOD, mg/L	322	384	322	384	322	384	322	384
- TSS, mg/L	504	634	504	634	504	634	504	634
- NH3-N, mg/L	30	35	30	35	30	35	30	35
- TKN, mg/L	40	47	40	47	40	47	40	47
SECONDARY EFFLUENT QUALITY, mg/L:								
- BOD (est.), mg/L	2	3	3	4	1	1	1	1
- TSS (nominal), mg/L	10	10	10	10	0	0	0	0
- NH3-N, mg/L	0.09	0.89	0.05	0.91	0.06	0.62	0.06	0.62
- NO3-N, mg/L	4.8	4.9	5.7	5.3	5.6	5.8	5.5	5.7
- NO2-N, mg/L	0.02	0.27	0.01	0.37	0.01	0.17	0.01	0.16
- T.I.N., mg/L	4.9	6.0	5.8	6.6	5.6	6.6	5.6	6.5
- Organic N, mg/L	2.0	2.1	2.1	2.3	1.6	1.8	1.6	1.7
- T.N., mg/L	6.9	8.2	7.9	8.9	7.3	8.3	7.2	8.2
PRIMARY CLARIFIERS								
- # of Clarifiers	0	0	3	3	-	-	-	-
- # in Service	0	0	3	3	-	-	-	-
- Diameter, feet	-	-	80	80	-	-	-	-
- Surface Overflow Rate, gpd/sf	-	-	666	941	-	-	-	-
- Solids in primary sludge, lb/day	-	-	27,116	43,854	-	-	-	-
AERATION BASINS								
- # of Basins	2	2	3	3	2	2	6	6
- # in Service	2	2	3	3	2	2	6	6
- Total Anoxic Volume in Service, MG	2.46	2.46	3.69	3.69	0.95	0.95	2.78	2.78
- Total Aerobic Volume in Service, MG	3.69	3.69	5.54	5.54	1.68	1.68	4.94	4.94
- Total Aeration Basin volume, MG	6.15	6.15	9.23	9.23	2.63	2.63	7.72	7.72
- Hydraulic Deten. Time, hr	43.9	31.2	22.2	15.8	18.4	13.1	18.2	12.8
- Operating Last-Pass MLSS, mg/L	2,500	3,000	2,500	3,000	8,050	8,070	8,050	8,070
- Design Temperature, deg C	19.0	12.4	19.0	12.4	19.0	12.4	19.0	12.4
- Solids in WAS, ppd	5,380	10,560	6,127	14,759	6,357	12,879	18,075	36,417
- Aerobic SRT, days	14.7	9.0	17.7	9.3	20.0	9.9	19.7	9.8
- Total SRT, days	24.6	15.1	29.5	15.5	31.9	15.8	31.3	15.6
- F/M, lb BOD Appl./lb MLSS-day	0.11	0.16	0.12	0.18	0.08	0.13	0.08	0.13
- Aer. BOD Loading, lb BOD/1000 cf-day	17	29	18	33	41	68	41	69
- ML Recirculation Ratio	4.3	4.3	4.3	4.8	0.0	0.0	0.0	0.0
- Process Air (est.), scfm	2,840	4,920	5,870	9,660	3,610	5,920	10,960	18,180
- Number of blowers (incl. standby)	3	3	5	5	3	3	7	7
- Blower capacity required (each), scfm	2,100	3,500	2,100	3,400	2,600	4,100	2,500	4,100
SECONDARY CLARIFIERS								
- # of Basins	2	2	4	4	-	-	-	-
- # in Service	1	2	3	4	-	-	-	-
- Diameter, feet	100	100	100	100	-	-	-	-
- Sec. Clarifier SOR, gpd/sf	419	293	419	440	-	-	-	-
- Sec. Clar. Solids Loading, lb/day-sf	12	11	12	17	-	-	-	-
- Clarifier Safety Factor (CSF)	3.0	3.5	3.0	2.3	-	-	-	-
-- CSF Target	2.3	2.0	2.3	2.0	-	-	-	-

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
TERTIARY FILTERS								
- # of Units	3	3	6	6	-	-	-	-
- # in Service	2	2	5	5	-	-	-	-
- Surface area per filter, sf	645	645	645	645	-	-	-	-
- Filtration surface area in service, sf	1,290	1,290	3,225	3,225	-	-	-	-
- Loading rate at average day flow, gpm/sf	1.8	2.5	2.1	3.0	-	-	-	-
- Loading rate at peak flow, gpm/sf	3.5	3.5	4.3	4.3	-	-	-	-
- Backwash flow, % of influent	2.5	2.5	2.5	2.5	-	-	-	-
MEMBRANE BIO-REACTOR								
- MLSS in Membrane Tanks, mg/L	-	-	-	-	10,000	10,000	10,000	10,000
- RAS Recirculation Ratio (Qr/Q)	-	-	-	-	4.0	4.0	4.0	4.0
- # of Membrane Zones (Basins)	-	-	-	-	3	3	7	7
- # of Membrane Cassettes per Zone	-	-	-	-	12	12	12	12
- Membrane Modules per Cassette	-	-	-	-	44	44	44	44
- Total Membrane Modules (Elements)	-	-	-	-	1,584	1,584	3,696	3,696
- Total Membrane Area, sf	-	-	-	-	538,560	538,560	1,256,640	1,256,640
- Average Operating Flux, gfd	-	-	-	-	6.0	8.3	7.7	10.8
- Peak Operating Flux, gfd	-	-	-	-	11.9	11.9	15.3	15.4
-- One Membrane Zone Out of Service, gfd	-	-	-	-	17.8	17.8	17.9	17.9
- Scrubbing Air Blowers Installed (1 standby)	-	-	-	-	4	4	8	8
- Blower Capacity, each, scfm	-	-	-	-	1,300	1,300	1,300	1,300
- Blower Motor Size, each, hp	-	-	-	-	70	70	70	70

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44

DETAILED CALCULATIONS:

RAW WASTEWATER (excluding Recycles)								
o Plant Flow Rate, mgd	3.2	4.5	9.6	13.4	3.2	4.5	9.6	13.4
o Flow Characteristic Ratios								
- Max Month/Annual Avg flow ratio	1	1.4	1	1.4	1	1.4	1	1.4
- Max Day/Annual Avg flow ratio	2.0	1.4	2.0	1.4	2.0	1.4	2.0	1.4
- Peak 4-hr Wet-W Flow/Annual Avg	2.0	2.0	2.0	2.0	3.0	2.1	3.0	2.1
o Wastewater Characteristics								
- BOD, mg/L, Annual Average	322	322	322	322	322	322	322	322
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective BOD, mg/L	322	384	322	384	322	384	322	384
- TSS, mg/L, Annual Average	504	504	504	504	504	504	504	504
-- Mass Load (lb/d) Peaking Factor	1	1.76	1	1.76	1	1.76	1	1.76
-- Effective TSS, mg/L	504	634	504	634	504	634	504	634
- Fpv, VSS fraction	0.86	0.86	0.87	0.87	0.87	0.87	0.87	0.87
-- Effective VSS, mg/L	434	546	438	551	438	551	438	551
- NH3-N, mg/L, Annual Average	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective NH3-N, mg/L	29.5	35.2	29.5	35.2	29.5	35.2	29.5	35.2
Organic-N, mg/L, Annual Average	10	10	10	10	10	10	10	10
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective Org-N, mg/L	10.0	11.9	10.0	11.9	10.0	11.9	10.0	11.9
- NO3-N + NO2-N, mg/L, Annual Average	0	0	0	0	0	0	0	0
- Alkalinity, mg/L, Annual Average	250	250	250	250	250	250	250	250
- Filterable ("soluble") BOD								
-- fraction, Fbf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
-- mg/L	64	77	64	77	64	77	64	77
- Fvu, Fraction VSS that is Unbiodeg	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
o Design Temperature, deg. C								
- Minimum (Winter)	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
- Maximum (Summer)	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
- Design	19.0	12.4	19.0	12.4	19.0	12.4	19.0	12.4
-- Total COD to BOD ratio	2.19	2.20	2.19	2.20	2.19	2.20	2.19	2.20
RECYCLE TO HEADWORKS/PRIM CLAR.S								
o Flow Rate, mgd								
- Backwash Flow	0.082	0.115	0.247	0.346	0.000	0.000	0.000	0.000
- Underflow/Filtrate/Return Flow	0.045	0.081	0.083	0.214	0.044	0.089	0.182	0.367
- Dewatering Centrate	0.025	0.049	0.110	0.186	0.030	0.061	0.070	0.143
- Total	0.152	0.245	0.440	0.746	0.074	0.149	0.252	0.510
o Wastewater Characteristics, mg/L								
- Total Recycle								
-- BOD	54	88	250	287	209	327	127	193
-- TSS	310	332	526	603	1,940	1,909	1,191	1,153
-- VSS	192	216	362	427	1,198	1,248	730	740
-- NH3-N	0	1	109	115	0	0	0	0
-- Organic-N	13	15	22	26	73	82	47	51
-- NO3-N + NO2-N	3	3	4	4	31	49	35	58
-- Alkalinity	88	71	516	798	110	100	115	105
-- Filterable ("soluble") BOD	0.6	0.7	175.9	175.4	0.5	0.6	0.6	0.8
-- Total soluble Organic N	1.1	1.1	2.5	2.5	2.2	2.3	2.0	2.1
-- Fpv, VSS fraction	0.62	0.65	0.69	0.71	0.62	0.65	0.61	0.64
- Fvu, Fraction VSS that is Unbiodeg	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
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Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
PRIMARY TREATMENT	N.I.S.	N.I.S.	In Service	In Service	N.I.S.	N.I.S.	N.I.S.	N.I.S.
o Flow Rate, mgd								
- Raw Wastewater			9.6	13.4				
- Recycle stream			0.44	0.75				
- Total Influent			10.0	14.2				
o Wastewater Characteristics, mg/L								
- BOD			319	379				
- TSS			505	632				
- VSS			435	545				
- NH3-N			33	39				
- Organic-N			11	13				
- NO3-N + NO2-N			0	0				
- Alkalinity			262	279				
- Filterable ("soluble") BOD			69	82				
- Fpv, VSS fraction			0.86	0.86				
o Max biodegradable frac of VSS, est., mg/L			0.86	0.86				
o Basin dimensions (inside)								
- Number of Basins			3	3				
- Number of Units in Service			3	3				
- Diameter, ft			80	80				
- Side Water Depth, ft			12	12				
- Surface Area per Basin, sf			5,027	5,027				
- Surface Area in Service, sf			15,080	15,080				
o Surface Overflow Rate, gpd/sf								
- At Design Flow			666	941				
- At Diurnal Peak Flow			866	874				
- At Peak WW Flow			1,332	1,344				
o Detention Time, hr			3.2	2.3				
o Chemically Enhanced Primary Treatment								
- CEPT applied? [Y=1; N=0]			0	0				
o Removal Efficiency, %								
- BOD Removal, %			48.2	43.9				
- TSS Removal, %			63.7	58.1				
- Non-volatile SS %, Rpn			70.0	64.2				
- Organic-N Removal, %			43.8	40.1				
o Primary Sludge								
- BOD removed, lb/d			13,007	19,986				
- Solids removed, lb/d								
-- Non-chemical primary solids			27,116	43,854				
-- Chemical solids from CEPT			0	0				
-- Total solids removed			27,116	43,854				
- Concentration, %			3.0	3.0				
- Flow Rate, mgd			0.108	0.175				
- Flow Rate, gpm			75	122				
- Organic N removed, lb/d			391	613				
o Primary Effluent Flow, mgd			9.9	14.0				
o Primary Effluent Characteristics, mg/L								
- BOD			165	213				
- TSS			183	265				
- VSS			162	233				
- NH3-N			33.0	39.4				
- Organic-N			5.91	7.60				
- NO3-N + NO2-N			0.2	0.2				
- Alkalinity			262	279				
- Filterable ("soluble") BOD			69	82				

CAROLLO ENGINEERS, PC	
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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
ACTIVATED SLUDGE PROCESS								
o Flow Rate, mgd								
- Total Main Influent to Activated Sludge	3.36	4.73	9.96	14.04	3.28	4.64	9.88	13.98
o Influent Characteristics, mg/L								
- Total BOD	309	368	165	212	319	381	316	376
- TSS	494	617	183	264	535	673	520	651
- VSS	422	528	162	233	454	573	445	557
- NH3-N	28	33	33	39	29	34	29	34
- Organic-N	10	12	6	8	11	14	11	13
- NO3-N + NO2-N	0	0	0	0	1	2	1	2
- Alkalinity	242	240	261	278	246	245	246	244
- Filterable ("soluble") BOD	61	73	69	82	63	74	63	74
- Fpv, VSS fraction	0.86	0.86	0.89	0.88	0.85	0.85	0.85	0.86
- AB Influent D.O. Concentration, mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o Basin dimensions								
- Main Basins								
-- No. of Basins	2	2	3	3	2	2	6	6
-- Number of Units in Service	2	2	3	3	2	2	6	6
-- Length, ft (inside)	220	220	220	220	200	200	200	200
-- Width, ft (inside)	110	110	110	110	47	47	47	47
-- Side Water Depth, ft	17	17	17	17	17	17	17	17
.. Recomm inside Wall height, incl. Freeboard, ft	20	20	20	20	22	22	22	22
-- Liquid Volume per Basin, mil gal	3.08	3.08	3.08	3.08	1.195	1.195	1.195	1.195
- Supplemental Basins or Sections								
-- Identification					Membrn Zn	Membrn Zn	Membrn Zn	Membrn Zn
-- No. of Basins	0	0	0	0	3	3	7	7
-- Number of Units in Service	0	0	0	0	3	3	7	7
-- Length, ft (inside)	0	0	0	0	21	21	21	21
-- Width, ft (inside)	0	0	0	0	48	48	48	48
-- Side Water Depth, ft	0	0	0	0	10.3	10.3	10.3	10.3
-- Volume per Basin, mil gal	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08
o Total Volume of Basins, mil gal								
- Total Basin volume in service	6.15	6.15	9.23	9.23	2.625	2.625	7.719	7.719
-- Reduction for MBR cassettes	0.00	0.00	0.00	0.00	0.101	0.101	0.236	0.236
- Biological Reaction Volume	6.15	6.15	9.23	9.23	2.524	2.524	7.483	7.483
o Aerated Zone BOD Loading, lb/1,000 cf-day	17.4	29.2	18.3	33.1	40.9	68.2	41.1	68.7
o Hydraulic Detention Time, hr	43.94	31.20	22.24	15.78	18.45	13.06	18.17	12.85
o Selected Operating L-P MLSS, mg/L	2,500	3,000	2,500	3,000	10,000	10,000	10,000	10,000
PROCESS LAYOUT								
o Zone Sizes (Fraction of Total Volume)								
- Zone 1	0.200	0.200	0.200	0.200	0.188	0.188	0.186	0.186
- Zone 2	0.200	0.200	0.200	0.200	0.188	0.188	0.186	0.186
- Zone 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 5	0.200	0.200	0.200	0.200	0.285	0.285	0.293	0.293
- Zone 6	0.200	0.200	0.200	0.200	0.285	0.285	0.293	0.293
- Zone 7	0.200	0.200	0.200	0.200	0.055	0.055	0.043	0.043
-- Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
o DO in each Zone (Unaerated, Set = 0), mg/L								
- Zone 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 7	2.0	2.0	2.0	1.0	5.2	4.1	5.0	3.9

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
o Aerated/Unaerated Fractions								
- Total Unaerated Volume Fraction	0.40	0.40	0.40	0.40	0.38	0.38	0.37	0.37
-- Total Unaerated Volume, mil gal	2.46	2.46	3.69	3.69	0.95	0.95	2.78	2.78
- Total Aerated Volume Fraction	0.60	0.60	0.60	0.60	0.62	0.62	0.63	0.63
-- Total Aerated Volume, mil gal	3.69	3.69	5.54	5.54	1.58	1.58	4.70	4.70
- Total Aerated Mass Fraction	0.60	0.60	0.60	0.60	0.63	0.63	0.63	0.63
o Plant Influent Flow Routing								
- Fraction to Zone 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
- Fraction to Zone 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Remainder to Zone 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Sludge Wasting Method								
- Wasting from RAS (1) or ML (0)	1	1	1	1	0	0	0	0
-- If ML, Waste taken from Zone # (1, 2, - - 7)	(RAS)	(RAS)	(RAS)	(RAS)	7	7	7	7
o Mixed-Liquor Recirculation (MLR#1) Routing								
- MLR Taken from Zone (0, 1, 2, - - 7); 0=NA	7	7	7	7	7	7	7	7
- MLR Returned to Zone (0, 1, 2, - - 7); 0=NA	1	1	1	1	1	1	1	1
- MLR Flow, mgd	14.40	20.16	43.20	67.20	0.00	0.00	0.00	0.00
- MLR Flow per train, mgd	5,000	7,000	10,000	15,555	0	0	0	0
- MLR Ratio	4.28	4.26	4.34	4.79	0.00	0.00	0.00	0.00
LOADING CRITERIA								
o BOD Applied, lb/d								
- BOD in Influent	8,662	14,532	13,693	24,852	8,722	14,759	26,048	43,873
- BOD in External Stream	0	0	0	0	0	0	0	0
- (-) WAS Recycled	50	133	110	326	107	369	206	709
- Net BOD Load	8,612	14,398	13,583	24,526	8,614	14,390	25,842	43,164
o MLSS under aeration, lb	77,273	92,756	115,759	138,899	108,268	108,544	321,073	321,854
- F/M, lb BOD Appl./lb MLSS-day	0.11	0.16	0.12	0.18	0.08	0.13	0.08	0.13
o Organic Loading, Based on Aerated Zone								
- Aerated Volume in Service, 1,000 cf	494	494	741	741	211	211	628	628
- Aer. BOD Loading, lb BOD/1000 cf-day	17.4	29.2	18.3	33.1	40.9	68.2	41.1	68.7
o Unaerated Zone								
- Actual HRT (Throughflow), hr	3.12	2.20	1.56	1.00	1.38	0.98	1.35	0.96
- Mixing Power, total								
-- Total BHP, all Unaerated Zones	86.2	86.2	129.2	129.2	33.1	33.1	97.4	97.4
-- Mixing, hp/mil gal	35	35	35	35	35	35	35	35
WAS SOLIDS PRODUCTION								
o Solids Production, TSS, lb/d								
- TSS Entering in Feed, lb/d	14,447	25,414	17,653	35,302	15,156	26,959	44,404	78,643
- TSS Entering in External Input, lb/d	0	0	0	0	0	0	0	0
- VSS Change in A.B. Zones	-8,941	-14,795	-10,966	-20,013	-8,955	-14,441	-26,793	-43,303
- ISS Change in A.B. Zones	148	324	264	624	156	361	464	1,077
- ISS due to Bio-P (Est.), lb/d	0	0	0	0	0	0	0	0
- Unbiodeg VSS due to Bio-P (Est.), lb/d	0	0	0	0	0	0	0	0
- Total Solids Production, lb/d	5,654	10,944	6,951	15,912	6,357	12,879	18,075	36,417

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
SOLIDS RETENTION TIME, SRT								
o Total Solids Wasted, lb/d	5,654	10,944	6,951	15,912	6,357	12,879	18,075	36,417
- Recycled WAS Solids, lb/d	393	679	401	908	954	1,932	1,808	3,642
- Net lb Solids Yield/day	5,261	10,265	6,549	15,005	5,403	10,947	16,268	32,776
o Total BOD Load, lb/d	8,612	14,398	13,583	24,526	8,614	14,390	25,842	43,164
- Recycled BOD, lb/d	50	133	110	326	107	369	206	709
- Net BOD Load, lb/d	8,562	14,265	13,472	24,200	8,507	14,021	25,636	42,456
o Solids Production								
- lb Dry SS/lb BOD Applied	0.614	0.720	0.486	0.620	0.635	0.781	0.635	0.772
o Total Mass TSS in System, lb	129,342	155,253	193,393	232,036	172,179	172,683	508,823	510,240
- Total SRT (Rs), days	24.59	15.12	29.53	15.46	31.87	15.77	31.28	15.57
o Total Mass TSS in Aerated Zones, lb	77,273	92,756	115,759	138,899	108,268	108,544	321,073	321,854
- Nominal Aerated Mass Fraction	0.597	0.597	0.599	0.599	0.629	0.629	0.631	0.631
- Nominal Aerobic SRT, days	14.69	9.04	17.67	9.26	20.04	9.92	19.74	9.82
o Min. Aer. SRT recommended for nitrification, days	3.8	9.5	3.8	10.0	3.7	9.0	3.7	9.0
- Washout SRT(total)								
-- Rwashout = 1/(Ua*DOsw - ba)	3.22	7.37	3.19	7.70	2.97	6.74	2.96	6.72
- Recommended Operating SRT								
-- Max slope criterion, as dNH3/dSRT, mg/L-d	0.31	0.13	0.32	0.12	0.34	0.14	0.34	0.14
-- Recomm. Min. Operating SRT(total)	6.4	15.8	6.3	16.6	5.9	14.3	5.8	14.3
-- Recomm. Min. Op. SRT(Nominal aerobic)	3.8	9.5	3.8	10.0	3.7	9.0	3.7	9.0
-- Nitrification Safety Factor	1.99	2.15	1.99	2.16	1.98	2.13	1.98	2.13
AERATION REQUIREMENTS								
o Oxygen Required, lb/d								
- Net Oxygen Demand in Zone 1	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 2	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 3	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 4	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 5	4,461	5,755	11,059	13,788	5,916	7,901	18,074	24,324
- Net Oxygen Demand in Zone 6	2,876	4,880	6,207	11,352	3,694	6,585	11,261	20,131
- Net Oxygen Demand in Zone 7	2,038	4,106	4,026	8,361	1,244	1,900	3,138	4,648
- (-) Oxygen provided by MBR Scouring	0	0	0	0	-1,244	-1,901	-3,138	-4,649
- Total Oxygen required lb/d	9,375	14,740	21,292	33,501	9,610	14,486	29,335	44,454
o Diffuser Analysis								
Note:								
All values of air and blower requirements given below are preliminary estimates, to be refined during detailed design								
o Oxygen Transfer Efficiency	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]
- Diffuser Type	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"
- Aeration Basin D.O. (Avg), mg/L	2.0	2.0	2.0	1.7	2.0	2.0	2.0	2.0
- Design Water Temperature, C	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
- Diffuser submergence, ft	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
- Air loading, scfm/unit [Note]	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr
- Floor Coverage	23.7 At/Ad	22.8 At/Ad	17.2 At/Ad	17.4 At/Ad	8.8 At/Ad	8.9 At/Ad	8.4 At/Ad	8.5 At/Ad

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
- Clean Water SOTE	27.5	26.4	30.3	28.7	33.8	32.3	33.9	32.5
- Site Conditions Adjustment Factor								
F = Actual / Standard OTE								
-- Alpha factor, including fouling	0.75	0.71	0.75	0.72	0.49	0.47	0.49	0.47
-- Theta factor	1.024	1.024	1.024	1.024	1.024	1.024	1.024	1.024
-- Temp. correction, Tau	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
-- Elevation above MSL, ft	4,910	4,910	4,910	4,910	4,910	4,910	4,910	4,910
-- ..Pressure correction, Omega	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
-- Beta factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
-- Equilibrium C*20	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66
..Depth Adjustment Factor	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
- F = Alpha x [Theta ^(T-20)]	0.47	0.45	0.47	0.48	0.31	0.30	0.31	0.30
x (Tau Beta Omega C*20 - C)/C*20								
- Oxygen Transfer Efficiency	13.07	11.85	14.37	13.72	10.55	9.68	10.60	9.68
OTE = F x SOTE	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Preliminary Estimate								
o SOTR Required								
- Average Day @ Design flow								
-- Actual Ox Tr Requd, AOTR, lb/d	9,375	14,740	21,292	33,501	9,610	14,486	29,335	44,454
-- Site Conditions Adjustment, F	0.47	0.45	0.47	0.48	0.31	0.30	0.31	0.30
-- Standard Ox Tr Rate, SOTR, lb/d	19,745	32,899	44,844	70,057	30,799	48,314	93,988	149,137
SOTR = AOTR / F								
o Air Supply Required								
- Average Day @ Design flow								
-- Ox Transfer Rate, AOTR, lb/d	9,375	14,740	21,292	33,501	9,610	14,486	29,335	44,454
-- Oxygen Supplied, lb/min	49.8	86.4	102.9	169.5	63.3	103.9	192.3	319.0
-- cf Air/lb Oxygen	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0
[23.3 lb O2/100 lb Air]								
[0.0753 lb Air/scf]								
-- Process Air, scfm	2,840	4,920	5,870	9,660	3,610	5,920	10,960	18,180
..scfm per lb/d Oxygen	0.303	0.334	0.276	0.288	0.376	0.409	0.374	0.409
..scf/lb BOD Applied	475	492	622	567	603	592	611	606
-- Other Uses, e.g. Channel Air	400	500	800	900	400	500	800	900
-- Total Blower Air, scfm	3,240	5,420	6,670	10,560	4,010	6,420	11,760	19,080
- Peak Day @ Design Flow								
-- Peaking factor	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
-- Process Air, scfm	3,700	6,400	7,600	12,600	4,700	7,700	14,200	23,600
-- Total Blower Air, scfm	4,100	6,900	8,400	13,500	5,100	8,200	15,000	24,500
o Diffusers								
- Expressed as active sq ft or # diffusers	dfr	dfr	dfr	dfr	dfr	dfr	dfr	dfr
- Recommended								
-- Air Loading, scfm/(sf or dfr)	0.95	1.59	0.95	1.59	0.95	1.59	0.95	1.59
-- Number recommended per Basin	1,494	1,552	2,058	2,030	1,898	1,867	1,923	1,910
- Actual Installed, per basin								
-- Main Basin	1,494	1,552	2,058	2,030	1,898	1,867	1,923	1,910
-- Additional Basin	0	0	0	0	0	0	0	0
- Total Installed, sf or dfr	2,988	3,104	6,174	6,090	3,796	3,734	11,535	11,462
- Air Loading, scfm/sf or dfr								
-- Daily Average	0.95	1.59	0.95	1.59	0.95	1.59	0.95	1.59
- Floor Coverage								
-- Total Basin Floor Area in Service, sf	48,400	48,400	72,600	72,600	21,845	21,845	63,505	63,505
-- Total Aerated Floor Area in service	29,040	29,040	43,560	43,560	13,652	13,652	39,897	39,897
-- Coverage	23.7	22.8	17.2	17.4	8.8	8.9	8.4	8.5
.. Expressed as	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad
- Active sf/diffuser, or 1	1	1	1	1	1	1	1	1
- Number of diffuser units	2,988	3,104	6,174	6,090	3,796	3,734	11,535	11,462

CAROLLO ENGINEERS, PC	
W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE
Calc by CL	Date Time 06/29/2010 9:42 AM / Chk by/Date

Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
o Blower Discharge pressure								
- Head, ft water								
-- Submergence	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
-- Freeboard above normal op level	0.0	0.0	0.0	0.0	4.0	4.0	4.0	4.0
-- Diffuser head loss	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
-- Pipe & Valve friction	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
-- Total Head, ft	19.6	19.6	19.6	19.6	23.6	23.6	23.6	23.6
- Discharge pressure, psig	8.5	8.5	8.5	8.5	10.2	10.2	10.2	10.2
o Delivered Horsepower								
- Max Operating Air Temp, C	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
- Barometric Pressure, psia	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3
- Blower Suction Pressure, psia	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
- Daily Average Total Air, scfm	3,240	5,420	6,670	10,560	4,010	6,420	11,760	19,080
- Avg Delivered Horsepower, hp	128	215	264	418	184	295	540	876
- Peak Day Delivered hp	162	273	333	535	234	377	689	1,125
o Wire power required								
- Energy Efficiency, %	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0
- Wire power required, hp								
-- Daily Average	210	350	430	690	300	480	890	1,440
-- Firm Installed	270	450	550	880	380	620	1,130	1,840
o Blower Capacity Required								
- Number of Blowers	3	3	5	5	3	3	7	7
- Capacity, each, scfm	2,100	3,500	2,100	3,400	2,600	4,100	2,500	4,100
- Firm Capacity, scfm	4,200	7,000	8,400	13,600	5,200	8,200	15,000	24,600
SECONDARY SEDIMENTATION BASINS								
o Flow Rates, mgd								
- AS Influent, Q	3.36	4.73	9.96	14.04				
- Net Sed. Basin Inflow (excl. RAS), Qci	3.36	4.73	9.96	14.04				
- Return Sludge Flow, Qr	1.21	2.02	3.62	7.13				
(not including waste sludge flow)								
- Total Sed Basin Inflow	4.57	6.76	13.58	21.17				
- Total Sed. Basin Underflow	1.28	2.16	3.70	7.34				
- Net Sec. Effluent, Qe	3.29	4.60	9.88	13.83				
o Basin dimensions								
- Group 1								
-- No. of Basins	2	2	4	4				
-- Number of Units in Service	1	2	3	4				
-- Diameter, ft (inside)	100	100	100	100				
-- Side Water Depth, ft	15	15	15	15				
-- Surface Area per Basin, sf	7,854	7,854	7,854	7,854				
-- Volume per Basin, cf	117,810	117,810	117,810	117,810				
o Surface Overflow Rate								
- Group 1								
-- Surface Area in service, sf	7,854	15,708	23,562	31,416				
-- Surface Overflow Rate, gpd/sf	419	293	419	440				
o Solids Loading Rate, lb/day-sf								
- Group 1	12	11	12	17				
o Volume in service, mil gal								
- Group 1	0.88	1.76	2.64	3.52				
o Hydraulic Detention Time, hr (based on Q)								
- Group 1	6.3	8.9	6.4	6.0				
o Weir Loading								
- Group 1								
-- Actual weir length per unit, ft	305	305	305	305				
-- Weir loading, gpd/ft	10,794	7,547	10,808	11,350				

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
o Sludge Settling Characteristics								
ISV = V_0 exp(- MLSS/X_M), ft/h								
- Design Settling Constants								
-- V_0, ft/hr	21.3	21.3	21.3	21.3				
-- X_M, mg/L	2,260	2,260	2,260	2,260				
o Target Settling Values								
- Effluent rise rate (SOR), ft/hr								
-- Average	2.33	1.63	2.34	2.45				
- Clarifier Safety Factor, CSF	2.30	2.00	2.30	2.00				
- Max. Initial Settling Velocity, ISV, ft/hr	5.4	3.3	5.4	4.9				
- Preferred Max. Last-Pass MLSS, mg/L	3,116	4,240	3,113	3,318				
o Selected Settling Values								
- Operating L-P MLSS conc, mg/L	2,500	3,000	2,500	3,000				
- Operating ISV, ft/h	7.05	5.65	7.05	5.65				
- Operating CSF								
-- Average	3.02	3.46	3.02	2.30				
SLUDGE RETURN AND WASTAGE								
o Wasting Method (see Process Layout)								
- Waste Flow from RAS, Qw	0.072	0.135	0.080	0.205	0.000	0.000	0.000	0.000
- Waste Flow from MLSS, Zone 7, Qmw	0.000	0.000	0.000	0.000	0.076	0.154	0.217	0.437
o Return Sludge								
- Qr/Q, fraction (based on Qr to Aer Basin)	0.36	0.43	0.36	0.51	4.00	4.00	4.00	4.00
-- [Clarifier Underflow fraction]	0.38	0.46	0.37	0.52	4.00	4.00	4.00	4.00
- RAS flow to Aer Basin, Qr, mgd Average	1.21	2.02	3.62	7.13	13.13	18.56	39.52	55.91
- RAS concentration, mg/L	8,911	9,374	9,146	8,639	10,000	10,000	10,000	10,000
o Sludge Wastage								
- Total Solids Wasted, lb/d	5,654	10,944	6,951	15,912	6,357	12,879	18,075	36,417
- Adjustment for ESS:								
-- Solids in Effluent, lb/d	274	384	824	1,154	0	0	0	0
-- Solids in WAS, lb/d	5,380	10,560	6,127	14,759	6,357	12,879	18,075	36,417
- Concentration, mg/L	8,911	9,374	9,146	8,639	10,000	10,000	10,000	10,000
- Organic N, lb/d	208	455	321	804	241	558	699	1,606
- Flow Rate, mgd Average	0.072	0.135	0.080	0.205	0.076	0.154	0.217	0.437
- Flow Rate, gpd Average	72,388	135,073	80,325	204,846	76,220	154,427	216,730	436,660
o WAS Characteristics, mg/L								
- Wasting from -	RAS	RAS	RAS	RAS	Zone 7	Zone 7	Zone 7	Zone 7
- BOD	1,157	1,809	1,547	2,167	1,125	1,910	1,141	1,946
- TSS	8,911	9,374	9,146	8,639	10,000	10,000	10,000	10,000
- VSS	5,514	6,090	6,515	6,311	6,285	6,679	6,302	6,680
- NH3-N	0.1	0.9	0.1	0.9	0.1	0.6	0.1	0.6
- Organic-N	344.9	404.0	478.7	470.7	379.3	433.4	386.6	441.0
- NO3-N + NO2-N	4.8	4.9	5.7	5.3	5.6	6.0	5.5	5.8
- Alkalinity	125	107	124	122	126	110	127	112
- Filterable ("soluble") BOD	0.8	1.0	0.8	1.0	0.9	1.0	0.9	1.0
- Total soluble Organic N	1.6	1.7	1.6	1.7	1.6	1.8	1.6	1.7
o Recommended Installed Capacity								
- Min. Underflow requ'd at peak flow, $Q_{Rmin,p}$	2.17	2.93	6.53	11.26				
- Thickening Safety Factor	1.10	1.10	1.10	1.10				
- Recomm. Underflow Capacity, mgd	2.39	3.23	7.18	12.38				
- Installed Return Sludge Pumps, mgd	2.32	3.09	7.10	12.18				
-- gpm	1,610	2,150	4,930	8,450				
- WAS Pumps								
-- Wasting operation, hr/day	24	24	24	24	24	24	24	24
-- Pump Capacity (2 x Qwas), gpm	110	190	120	290	110	220	310	610
-- WAS Solids Peak Handling Capacity, lb/hr	450	890	520	1,230	530	1,080	1,510	3,040

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
SECONDARY EFFLUENT								
o Flow Rate								
- Net Secondary Effluent, mgd	3.29	4.60	9.88	13.83	3.21	4.48	9.66	13.54
o Secondary Effluent Quality								
- BOD, mg/L	2	3	3	4	1	1	1	1
- TSS (nominal), mg/L	10	10	10	10	0	0	0	0
- VSS, mg/L	6.2	6.5	7.1	7.3	0.0	0.0	0.0	0.0
- NH3-N, mg/L	0.1	0.9	0.1	0.9	0.1	0.6	0.1	0.6
- Total Organic N, mg/L	2.0	2.1	2.1	2.3	1.6	1.8	1.6	1.7
- NO3-N, mg/L	4.8	4.9	5.7	5.3	5.6	5.8	5.5	5.7
- NO2-N, mg/L	0.0	0.3	0.0	0.4	0.0	0.2	0.0	0.2
- Alkalinity, mg/L	125	107	124	122	126	110	127	112
- Soluble Organic N, mg/L	1.6	1.7	1.6	1.7	1.6	1.8	1.6	1.7
- T.I.N., mg/L	4.9	6.0	5.8	6.6	5.6	6.6	5.6	6.5
- Total N, mg/L	6.9	8.2	7.9	8.9	7.3	8.3	7.2	8.2
TERTIARY FILTRATION	In Service	In Service	In Service	In Service	N.I.S.	N.I.S.	N.I.S.	N.I.S.
o Tertiary Filtration in Service? (Y=1, N=0)	1	1	1	1				
o Influent								
- Flow, mgd								
-- Total	3.3	4.6	9.9	13.8				
- BOD, total, mg/L	2.0	3.0	3.0	4.0				
- SS, total, mg/L	10.0	10.0	10.0	10.0				
o Filter Area								
- Surface Area per Filter, sf	645	645	645	645				
- Backwash - Continuous (0) or Intermittent (1)?	0	0	0	0				
- Standby Units Provided	1	1	1	1				
- Number of Filters								
-- Total	3	3	6	6				
- Number of Units in Service	2	2	5	5				
o Filter Loading								
- Surface Area in Service, sf	1,290	1,290	3,225	3,225				
- Liquid Loading Rate, gpm/sf								
-- At Daily Average Flow, gpm/sf	1.8	2.5	2.1	3.0				
-- At Peak Flow, gpm/sf	3.5	3.5	4.3	4.3				
o Removal								
- SS Removal, %	60	60	60	60				
- SS removed, lb/d	165	230	494	692				
- BOD removed, lb/d	20	46	108	208				
o Backwash Flow								
- Percent of Flow, %	2.5	2.5	2.5	2.5				
- Backwash Flow, mgd	0.08	0.11	0.25	0.35				
o Backwash Characteristics, mg/L								
- BOD	29	49	53	73				
- TSS	240	240	240	240				
- VSS	149	156	171	175				
- NH3-N	0.1	0.9	0.1	0.9				
- Organic-N	11	12	14	15				
- NO3-N + NO2-N	4.8	5.1	5.7	5.7				
- Alkalinity	125	107	124	122				
o Net Flow to Disinfection, mgd								
- To Disinfection	3.21	4.48	9.63	13.49	3.21	4.48	9.66	13.54

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
o Tertiary Effluent Quality, mg/L								
- BOD	1.3	1.8	1.7	2.2	0.9	1.0	0.9	1.0
- SS	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0
- VSS, mg/L	2.5	2.6	2.8	2.9	0.0	0.0	0.0	0.0
- NH3-N, mg/L	0.1	0.9	0.1	0.9	0.1	0.6	0.1	0.6
- Total Organic N, mg/L	1.8	1.9	1.8	1.9	0.0	0.0	0.0	0.0
- NO3-N + NO2-N, mg/L	4.8	5.1	5.7	5.7	5.6	6.0	5.5	5.8
- Alkalinity, mg/L	125	107	124	122	126	110	127	112
- Filterable ("soluble") BOD	0.8	1.0	0.8	1.0	0.9	1.0	0.9	1.0
- Soluble Organic N, mg/L	1.6	1.7	1.6	1.7	1.6	1.8	1.6	1.7
- T.I.N., mg/L	4.9	6.0	5.8	6.6	5.6	6.6	5.6	6.5
- Total N, mg/L	6.7	7.9	7.6	8.5	5.6	6.6	5.6	6.5
RESIDUALS MANAGEMENT								
SOLIDS GENERATED								
o Total Primary Sludge								
- Flow, mgd	0.000	0.000	0.108	0.175	0.000	0.000	0.000	0.000
- Solids, lb/d	0	0	27,116	43,854	0	0	0	0
- Concentration, %	2.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0
- VSS, %	100	100	85	85	100	100	100	100
- Volatile solids, lb/d	0	0	22,995	37,168	0	0	0	0
- Organic N, lb/d	0	0	391	613	0	0	0	0
o Total Waste Activated Sludge								
- Flow, mgd	0.072	0.135	0.080	0.205	0.076	0.154	0.217	0.437
- Solids, lb/d	5,380	10,560	6,127	14,759	6,357	12,879	18,075	36,417
- Concentration, %	0.89	0.94	0.91	0.86	1.00	1.00	1.00	1.00
- VSS, %	62	65	71	73	63	67	63	67
- Volatile solids, lb/d	3,329	6,860	4,365	10,782	3,995	8,602	11,391	24,327
- Organic N, lb/d	208	455	321	804	241	558	699	1,606
SLUDGE ROUTING								
o Primary Sludge								
- (a) Thickening	None	None	None	None	None	None	None	None
- (b) Then routed to - -	N.A.	N.A.	Anaer Digs	Anaer Digs	N.A.	N.A.	N.A.	N.A.
o Waste Activated Sludge								
- (a) Thickening	Grav Thkr	Grav Thkr	GBT	GBT	Grav Thkr	Grav Thkr	GBT	GBT
- (b) Then routed to - -	Dewatering	Dewatering	Anaer Digs	Anaer Digs	Aero Diges	Aero Diges	Aero Diges	Aero Diges
GRAVITY THICKENERS	In Service	In Service	NA	NA	In Service	In Service	NA	NA
o Service	WAS	WAS			WAS	WAS		
o Sludge Feed								
- Flow, mgd	0.072	0.135			0.076	0.154		
- Solids, lb/d	5,380	10,560			6,357	12,879		
- Concentration, %	0.9	0.9			1.0	1.0		
o Basin dimensions								
- No. of Basins	1	1			1	1		
- Number of Units in Service	1	1			1	1		
- Diameter, ft (inside)	60	60			60	60		
- Total Effective Area, sf	2,734	2,734			2,734	2,734		
o Thickener Loading								
- Solids Loading, lb/hr-sf	0.08	0.16			0.10	0.20		
– Hydraulic Loading, gpd/sf	26	49			28	56		
o Thickened Sludge								
- Solids Capture, %	85	85			85	85		
- Thk Sl Solids, lb/d	4,573	8,976			5,403	10,947		
- Thk Sl Solids, %	2.0	2.0			2.0	2.0		
- Thk Sl Flow, mgd	0.027	0.054			0.032	0.066		

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Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
GRAVITY BELT THICKENING	NA	NA	GBT	GBT	NA	NA	GBT	GBT
o Service			WAS	WAS			WAS	WAS
o Sludge Feed								
- Flow rate, mgd			0.080	0.205			0.217	0.437
-- Operating hours per Week			42	42			42	42
-- Recomm Installed Capacity, gpm			446	1,137			1,203	2,424
- Total Solids, lb/d			6,127	14,759			18,075	36,417
-- Recomm Installed Capacity, lb/hr			149	379			401	808
o Number of Units			3	3			3	3
- Number of Units in Service			2	2			2	2
- Feed Rate, Rotary Drum Thickener:			NA	NA			NA	NA
-- gpm per unit			400	400			400	400
- Feed Rate, Gravity Belt			GBT	GBT			GBT	GBT
-- Belt width, m			2	2			2	2
-- Feed Rate, gpm per meter			250	250			250	250
-- gpm per unit			500	500			500	500
- Operating cycle								
-- days/week			5	5			5	5
-- hours/day (calc)			1.9	4.8			5.1	10.2
o Thickened Solids								
- Solids Capture, %			90	90			90	90
- Thickened Solids, lb/d			5,514	13,283			16,268	32,776
- Concentration, %			5.0	5.0			2.50	2.50
- Flow Rate, mgd Average			0.013	0.032			0.078	0.157
- Volatile Solids, lb/d			3,928	9,704			10,252	21,894
- Organic N, lb/d			289	724			629	1,445
- Recomm Installed Pump Capacity, gpm			6	16			33	65
o Combined Filtrate & Wash Water								
- Unrecovered Solids, lb/d			613	1,476			1,808	3,642
- Flow								
-- Filtrate, mgd			0.067	0.173			0.139	0.279
-- Wash water, mgd/mgd feed			0.2	0.2			0.2	0.2
. . Wash Water flow, mgd (daily average)			0.016	0.041			0.043	0.087
-- Total Flow, mgd			0.083	0.214			0.182	0.367
- Characteristics, mg/L								
-- BOD			149	207			136	232
-- TSS			883	827			1,190	1,190
-- VSS			629	604			750	795
-- NH3-N			0.1	0.9			0.1	0.6
-- Organic-N			48	47			48	54
-- NO3-N + NO2-N			5.7	5.4			5.5	5.8
-- Alkalinity			124	122			127	112
OUTPUT FROM WAS THICKENING (OR CO-THICK)	Grav Thkr	Grav Thkr	GBT	GBT	Grav Thkr	Grav Thkr	GBT	GBT
o Thickened Sludge	WAS	WAS	WAS	WAS	WAS	WAS	WAS	WAS
- Total Solids, lb/d	4,573	8,976	5,514	13,283	5,403	10,947	16,268	32,776
- Percent Solids, %	2.0	2.0	5.0	5.0	2.0	2.0	2.5	2.5
- Flow Rate, mgd Average	0.027	0.054	0.013	0.032	0.032	0.066	0.078	0.157
- Volatile Solids, lb/d	2,830	5,831	3,928	9,704	3,396	7,312	10,252	21,894
- Organic N, lb/d	177	387	289	724	205	475	629	1,445
o Underflow/Filtrate/Return Flow								
- Flow, mgd	0.045	0.081	0.083	0.214	0.044	0.089	0.182	0.367
- Characteristics, mg/L								
-- BOD	280	452	149	207	294	499	136	232
-- TSS	2,152	2,337	883	827	2,609	2,609	1,190	1,190
-- VSS	1,331	1,518	629	604	1,639	1,742	750	795
-- NH3-N	0	1	0	1	0	1	0	1
-- Organic-N	83	101	48	47	99	113	48	54
-- NO3-N + NO2-N	0.0	0.0	5.7	5.4	0.0	0.0	5.5	5.8
-- Alkalinity	125	107	124	122	126	110	127	112

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
ANAEROBIC DIGESTION	NA	NA	In Service	In Service	NA	NA	NA	NA
o Digester Feed								
- Flow, total, mgd			0.122	0.207				
-- Primary Sludge			0.108	0.175				
-- Waste Activated Sludge			0.013	0.032				
- Solids, total, lb/d			32,631	57,137				
-- Primary Sludge			27,116	43,854				
-- Waste Activated Sludge			5,514	13,283				
-- Ratio, Primary/Total			0.83	0.77				
- Volatile Solids, total, lb/d			26,923	46,872				
-- Primary Sludge			22,995	37,168				
-- Waste Activated Sludge			3,928	9,704				
- Organic N, total, lb/d			680	1,337				
o Digester Size								
- Group 1 Units								
-- Number			1	1				
-- Diameter, ft			85	85				
-- SWD, ft			25.5	25.5				
-- Volume per Digester, kcf			144.7	144.7				
- Group 2 Units								
-- Number			3	3				
-- Diameter, ft			85	85				
-- SWD, ft			25.5	25.5				
-- Volume per Digester, kcf			144.7	144.7				
- Gross Volume, kcf								
-- All Units in Service			579	579				
-- One Unit OOS			434	434				
- Allowance for grit, percent			5	5				
- Effective Volume, kcf								
-- All Units in Service			550	550				
-- One Unit OOS			412	412				
o Loading								
- VSS Loading, lb VSS/cf-d								
-- All Units in Service			0.049	0.085				
-- One Unit OOS			0.065	0.114				
- Detention Time, days								
-- All Units in Service			34	20				
-- One Unit OOS			25	15				
o Digested Sludge								
- VSS destruction, %			60	54				
- VSS destroyed, lb/d			16,136	25,485				
- Digested Sludge Flow Rate, mgd			0.120	0.204				
- Discharge Total Solids, lb/d			16,494	31,652				
-- TSS, %			1.65	1.86				
-- VSS, %			65.4	67.6				
o Gas Production								
- cf/lb VSS destroyed			15	15				
- Gas Production, kcf/d			242	382				
o Nitrogen in Dig Sludge Filtrate								
- Assumed Sol OrgN in Digester effl, mg/L			5	5				
- Org N/VSS in Digester Solids			0.025	0.028				
- VSS destroyed, lb/d			16,136	25,485				
- Ammonia generated, lb/d			404	722				
- NH3 Concentration, mg/L			434.67	457.71				
- Alkalinity, mg/L			1,691	2,833				
o Digested Sludge Routing			Dewat	Dewat				

CAROLLO ENGINEERS, PC	
W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE
Calc by Date Time	Chk by/Date
CL 06/29/2010 9:42 AM	

Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
AEROBIC DIGESTER	NA	NA	NA	NA	In Service	In Service	In Service	In Service
o Feed					WAS	WAS	WAS	WAS
- Flow, mgd					0.032	0.066	0.078	0.157
- Solids, lb/d					5,403	10,947	16,268	32,776
- Volatile Solids, lb/d					3,396	7,312	10,252	21,894
- Organic N, total, lb/d					205	475	629	1,445
o VSS destruction								
- VSS destroyed, %					20.1	27.7	22.6	34.8
- VSS destroyed, lb/d					682	2,022	2,317	7,628
- Solids remaining, lb/d					4,721	8,925	13,951	25,148
- Undecanted concentration, mg/L					17,475	16,305	21,439	19,182
- VSS fraction remaining					0.57	0.59	0.57	0.57
o Decant/Return								
- Sludge Conc., mg/L					17,475	16,305	21,439	19,182
o Basin Sizes								
- Existing tankage in service								
-- Number of basins					1	1	1	1
-- Oxidation ditch volume, mgal					0.875	0.875	0.875	0.875
- Number of new digester units in service					0	0	5	6
-- Area, each, sf					6,806	6,806	6,806	6,806
-- Depth, ft					20	20	20	20
-- Total volume, mil gal					0.88	0.88	5.97	6.98
o Detention Time								
- Solids retention time, d					27	13	76	44
-- Temperature, C					19.0	12.4	19.0	12.4
-- T x SRT					512	165	1,449	551
- Total SRT incl Aer Basin, days					59	29	108	60
-- T x SRT					1,116	361	2,042	744
o Oxygen required								
- VSS destruction								
-- lb O2/lb VSS destroyed					1.42	1.42	1.42	1.42
-- lb O2 used, lb/d					969	2,872	3,291	10,831
- Nitrification								
-- N released					41	131	142	502
-- lb O2 used for nitrif, lb/d					187	597	647	2,292
- Percent denitrified by intermittent operation					50	50	50	50
-- lb O2 recovered, lb/d					-59	-187	-202	-717
- Total Oxygen used, lb/d					1,097	3,282	3,735	12,406
o Aeration Method								
Surface Aeration (1) or Coarse-Bubble Air (2)?					2	2	2	2
o Diffused Aeration					Coarse B	Coarse B	Coarse B	Coarse B
- Oxygen Transfer Rate, scfm/(lb O2/day)					1.10	1.10	1.10	1.10
- Air Required, scfm					1,207	3,611	4,109	13,647
- Hours aerating per day					16	16	16	16
- Air Supply, scfm					1,811	5,416	6,163	20,470
- Mixing Air, scfm/sf					0.18	0.18	0.18	0.18
- Mixing Air, scfm					0	0	6,126	7,351
- Controlling Air Rate, scfm					1,811	5,416	6,163	20,470
o Digested Sludge								
- Flow Rate, mgd					0.032	0.066	0.078	0.157
- Characteristics, mg/L								
-- BOD					307	849	150	378
-- TSS					17,475	16,305	21,439	19,182
-- VSS					10,044	9,664	12,194	10,882
-- NH3-N					0	0	0	0
-- Organic-N					607	628	749	720
-- NO3-N + NO2-N					77	121	110	193
-- Alkalinity					85	85	85	85
o Digested Sludge Routing					Dewat	Dewat	Dewat	Dewat

CAROLLO ENGINEERS, PC	
W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Capacity Evaluation
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Calc by Date Time	Chk by/Date
CL 06/29/2010 9:42 AM	

Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 3 Design AADF	MLE Ph 3 Design MMADF Winter	MBR Ph 1 Design AADF	MBR Ph 1 Design MMADF Winter	MBR Ph 3 Design AADF	MBR Ph 3 Design MMADF Winter
Annual Average Plant Flow, mgd	3.20	3.20	9.60	9.60	3.20	3.20	9.60	9.60
Design (Max-Month) Flow, mgd	3.20	4.48	9.60	13.44	3.20	4.48	9.60	13.44
CENTRIFUGE DEWATERING	In Service	In Service	In Service	In Service	In Service	In Service	In Service	In Service
o Sludge Feed								
- Flow Rate, mgd	0.027	0.054	0.120	0.204	0.032	0.066	0.078	0.157
- Total Solids, lb/d	4,573	8,976	16,494	31,652	4,721	8,925	13,951	25,148
- Total VSS, lb/d	2,830	5,831	10,787	21,387	2,714	5,290	7,935	14,267
o Number of Centrifuges	2	2	3	3	2	2	3	3
- Number of Units in Service	1	2	2	2	1	2	2	2
- Feed Rate, gpm per unit	70	70	200	200	70	70	200	200
- Operating cycle								
-- days/week	6	6	6	6	6	6	6	6
-- hours/day (calc)	7.6	7.5	5.8	9.9	9.0	9.1	3.8	7.6
o Sludge Cake								
- Capture, %	95	95	95	95	95	95	95	95
- Concentration, %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
- Cake Solids, lb/d								
-- Dry Solids, lb/d	4,344	8,527	15,670	30,070	4,485	8,479	13,253	23,891
-- Wet Cake, tons/d	10.9	21.3	39.2	75.2	11.2	21.2	33.1	59.7
- Flow, mgd	0.0026	0.0051	0.0094	0.0180	0.0027	0.0051	0.0079	0.0143
o Dewatering Centrate								
- Flow, mgd	0.025	0.049	0.110	0.186	0.030	0.061	0.070	0.143
- Characteristics, mg/L								
-- BOD	233	329	769	775	83	75	105	93
-- TSS	1,105	1,105	897	1,020	953	884	1,193	1,055
-- VSS	684	718	586	689	548	524	679	599
-- NH3-N	0	1	435	458	0	0	0	0
-- Organic-N	44	49	20	25	36	37	45	42
-- NO3-N + NO2-N	5	5	0	0	77	121	110	193
-- Alkalinity	125	107	1,691	2,833	85	85	85	85

APPENDIX B

COST ESTIMATES

AACE COST ESTIMATE DEFINITIONS

AACEI Cost Estimate Classification Matrix for Process Industries[1]

		Primary Characteristic	Secondary Characteristic			
		Level of Project Definition	End Usage	Methodology	Expected Accuracy Range	Preparation Effort
ANSI Standard Z94.0	AACE Estimate Class	Expressed as % of complete project definition (engineering)	Typical purpose of the estimate	Typical estimating method	Typical variation in low and high ranges (a)	Typical degree of effort relative to least cost index of 1 (b)
Order-of-Magnitude Estimate -30/+50	Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%	1
Budget Estimate -15/+30	Class 4	1% to 15%	Study or feasibility	Equipment factored, or parametric models	L: -15% to -30% H: +20% to +50%	2 to 4
	Class 3	10% to 40%	Budget, authorization, or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%	3 to 10
Definitive Estimate -5/+15	Class 2	30% to 70%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%	4 to 20
	Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes:

(a) The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency. (b) If the cost index value of "1" represents 0.005 percent, then an index value of 100 represents 0.5 percent. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

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CAPITAL COST ESTIMATE

BUILDOUT (9.6 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

		Estimate Class:	4
Project:	Prescott Airport and Sundog WRF Technology Assessments	PIC:	J. Doller
Job #:	8286A.00	PM:	M. Courtney
Location:	Prescott, Az	Date:	June 17, 2010
Zip Code:	86301	By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION		TOTAL
01	General Conditions		$10,970,000
02	Headworks/Screening		$1,574,000
03	Grit Removal		$978,000
04	Splitter Boxes		$583,000
05	Primary Clarification		$4,929,000
06	Aeration System		$6,944,000
07	Blower Building		$1,445,000
08	Secondary Clarification		$6,852,000
09	RAS/WAS Pump Station		$539,000
10	Tertiary Filtration		$3,784,000
11	Disinfection		$5,251,000
12	Effluent Pump Station		$429,000
13	Solids Handling		$9,920,000
14	Anaerobic Digesters		$16,200,000
15	Administration / Maintenance Building		$1,731,000
16	Odor Control		$4,137,000
17	Miscellaneous Onsite		$7,836,000
	TOTAL DIRECT COST		**$84,102,000**
	Contingency	20.0%	$16,820,400
	Subtotal		**$100,922,400**
	General Contractor Overhead, Profit & Risk	15.0%	$15,138,360
	Subtotal		**$116,060,760**
	Escalation to Mid-Point	0.0%	$0
	Subtotal		**$116,060,760**
	Sales Tax	5.0%	$5,803,038
	Subtotal		**$121,863,798**
	Bid Market Allowance	0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST		**$121,863,798**

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	**GENERAL CONDITIONS**	0.15	%	73,132,000	10,969,800	1.00	10,969,800
						SUBTOTAL	*$ 10,969,800*
2	**HEADWORKS/ SCREENING**						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	800
	Structural Backfill	13	CY	40	533	1.00	533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	150,400
	Headworks Building	3,200	SF	150	480,000	1.00	480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	2	EA	190,821	381,642	1.00	381,642
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	61,800
	Misc. Mechanical (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	103,683
	Misc. Electrical (20% of equip)	0.20	%	443,442	88,688	1.00	88,688
	Misc. I&C (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
						SUBTOTAL	*$ 1,573,713*
3	**GRIT REMOVAL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	188	CY	800	150,400	1.00	150,400
	Misc. Metals, Wood & Plastics, Finishes,	1	LS	99,526	99,526	1.00	99,526
	PROCESS / MECHANICAL						
	Vortex Grit System	2	EA	242,486	484,972	1.00	484,972
	Misc. Mechanical (15% of equip)	0.15	%	484,972	72,746	1.00	72,746
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	484,972	96,994	1.00	96,994
	Misc. I&C (15% of equip)	0.15	%	484,972	72,746	1.00	72,746
						SUBTOTAL	*$ 977,385*

Carollo

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
4	**SPLITTER BOX**						
	CIVIL / SITE WORK						
	Excavation (soil)	5,348	CY	15	80,215	1.00	80,215
	Backfill (soil)	3,473	CY	20	69,450	1.00	69,450
	Structural Backfill	139	CY	40	5,556	1.00	5,556
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	300	CY	800	240,000	1.00	240,000
	Misc. Metals	3	LS	15,902	47,705	1.00	47,705
	Misc. FRP Weirs	120	LF	90	10,824	1.00	10,824
	PROCESS / MECHANICAL						
	Stainless Steel Gates	10	EA	8,589	85,891	1.00	85,891
	Misc. Mechanical (15% of equip)	0.15	%	85,891	12,884	1.00	12,884
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	85,891	17,178	1.00	17,178
	Misc. I&C (15% of equip)	0.15	%	85,891	12,884	1.00	12,884
						SUBTOTAL	***$ 582,586***
5	**PRIMARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	19,400	CY	15	290,997	1.00	290,997
	Backfill (soil)	7,112	CY	20	142,234	1.00	142,234
	Structural Backfill	1,117	CY	40	44,684	1.00	44,684
	ARCHITECTURAL / STRUCTURAL						
	Clarifier - Concrete	1,791	CY	800	1,432,752	1.00	1,432,752
	Sludge PS - Concrete	194	CY	600	116,670	1.00	116,670
	Clarifier Dome Covers	3	EA	290,000	870,000	1.00	870,000
	FRP Weirs & Baffles	3	LS	25,000	75,000	1.00	75,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	3	EA	400,000	1,200,000	1.00	1,200,000
	Sludge Pumps	2	EA	39,150	78,299	1.00	78,299
	Scum Pumps	2	EA	13,050	26,100	1.00	26,100
	Misc. Mechanical (15% of equip)	0.15	%	1,304,399	130,440	1.00	130,440
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,304,399	260,880	1.00	260,880
	Misc. I&C (15% of equip)	0.15	%	1,304,399	260,880	1.00	260,880
						SUBTOTAL	***$ 4,928,935***

Carollo

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
6	AERATION SYSTEM						
	CIVIL / SITE WORK						
	Excavation (soil)	69,709	CY	15	1,045,634	1.00	1,045,634
	Backfill (soil)	13,238	CY	20	264,755	1.00	264,755
	Structural Backfill	5,378	CY	40	215,128	1.00	215,128
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	6,763	CY	600	4,057,733	1.00	4,057,733
	PROCESS / MECHANICAL						
	Submersible Mixers	6	EA	29,624	177,744	1.00	177,744
	MLR Pumps	6	EA	30,812	184,872	1.00	184,872
	Fine Bubble Diffuser System	3	LS	181,326	543,977	1.00	543,977
	Misc. Mechanical (15% of equip)	0.15	LS	906,593	135,989	1.00	135,989
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	906,593	181,319	1.00	181,319
	Misc. I&C (15% of equip)	0.15	%	906,593	135,989	1.00	135,989
						SUBTOTAL	***$ 6,943,140***
7	BLOWER BUILDING						
	CIVIL / SITE WORK						
	Excavation (soil)	40	CY	15	600	1.00	600
	Structural Backfill	10	CY	40	400	1.00	400
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,800	SF	150	270,000	1.00	270,000
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	5	EA	139,398	696,991	1.00	696,991
	Misc. Mechanical (15% of equip)	0.15	%	696,991	104,549	1.00	104,549
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,800	SF	39	69,986	1.00	69,986
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,800	SF	32	58,322	1.00	58,322
	Misc. Electrical (20% of equip)	0.20	%	696,991	139,398	1.00	139,398
	Misc. I&C (15% of equip)	0.15	%	696,991	104,549	1.00	104,549
						SUBTOTAL	***$ 1,444,795***
8	SECONDARY CLARIFICATION						
	CIVIL / SITE WORK						
	Excavation (soil)	37,453	CY	15	561,795	1.00	561,795
	Backfill (soil)	11,853	CY	20	237,056	1.00	237,056
	Structural Backfill	2,327	CY	40	93,092	1.00	93,092
	ARCHITECTURAL / STRUCTURAL						
	Secondary Clarifiers - Concrete	4,100	CY	800	3,280,000	1.00	3,280,000
	Misc. FRP Baffles and Weirs	4	EA	25,000	100,000	1.00	100,000

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	4	EA	430,000	1,720,000	1.00	1,720,000
	Misc. Mechanical (15% of equip)	0.15	%	1,720,000	258,000	1.00	258,000
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,720,000	344,000	1.00	344,000
	Misc. I&C (15% of equip)	0.15	%	1,720,000	258,000	1.00	258,000
						SUBTOTAL	*$ 6,851,943*
9	RAS WAS PUMP STATION						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	23,150
	Structural Backfill	46	CY	40	1,852	1.00	1,852
	ARCHITECTURAL / STRUCTURAL						
	RAS P. S. - Slab/Footing	35	CY	580	20,300	1.00	20,300
	RAS P. S. - Walls	116	CY	710	82,360	1.00	82,360
	RAS P. S. - Elevated Slab	35	CY	840	29,169	1.00	29,169
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	RAS Pumps	4	EA	40,740	162,960	1.00	162,960
	WAS Pumps	3	EA	11,940	35,820	1.00	35,820
	Scum Pumps	4	EA	7,000	28,000	1.00	28,000
	Misc. Mechanical (15% of equip)	0.15	LS	226,780	34,017	1.00	34,017
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	226,780	45,356	1.00	45,356
	Misc. I&C (15% of equip)	0.15	%	226,780	34,017	1.00	34,017
						SUBTOTAL	*$ 538,739*
10	TERTIARY FILTRATION						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	Excavation and backfill	1	LS	96,133	96,133	1.00	96,133
	ARCHITECTURAL / STRUCTURAL						
	Filter basins and channels - walls	271	CY	830	224,561	1.00	224,561
	Filter basins and channels - slabs	117	CY	520	60,667	1.00	60,667
	Misc - Metals	1	LS	174,416	174,416	1.00	174,416
	PROCESS / MECHANICAL						
	Disk Filters Equipment	1	LS	1,940,002	1,940,002	1.00	1,940,002
	Chemical feed	1	LS	82,056	82,056	1.00	82,056
	Filter Inlet gates	6	EA	8,002	48,012	1.00	48,012
	Channel gates	3	EA	15,450	46,350	1.00	46,350
	Effluent weir gate	1	EA	16,450	16,450	1.00	16,450
	Sump pump	1	EA	18,616	18,616	1.00	18,616
	Misc. Mechanical (15% of equip)	0.15	%	2,151,486	322,723	1.00	322,723

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,151,486	430,297	1.00	430,297
	Misc. I&C (15% of equip)	0.15	%	2,151,486	322,723	1.00	322,723
						SUBTOTAL	***$ 3,783,005***
11	**DISINFECTION**						
	CIVIL / SITE WORK						
	Excavation (soil)	486	CY	15	7,295	1.00	7,295
	Backfill (soil)	198	CY	20	3,966	1.00	3,966
	Structural Backfill	80	CY	40	3,200	1.00	3,200
	ARCHITECTURAL / STRUCTURAL						
	UV Channels - Slab/Footing	40	CY	580	23,202	1.00	23,202
	UV Channels - Walls	53	CY	710	37,743	1.00	37,743
	PROCESS / MECHANICAL						
	UV Equipment	12	LS	287,500	3,450,000	1.00	3,450,000
	Misc. Mechanical (15% of equip)	0.15	LS	3,450,000	517,500	1.00	517,500
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	3,450,000	690,000	1.00	690,000
	Misc. I&C (15% of equip)	0.15	%	3,450,000	517,500	1.00	517,500
						SUBTOTAL	***$ 5,250,407***
12	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	32,410
	Structural Backfill	74	CY	40	2,963	1.00	2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	5	EA	32,342	161,711	1.00	161,711
	Misc. Mechanical (15% of equip)	0.15	LS	161,711	24,257	1.00	24,257
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	161,711	32,342	1.00	32,342
	Misc. I&C (15% of equip)	0.15	%	161,711	24,257	1.00	24,257
						SUBTOTAL	***$ 428,249***

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
13	SOLIDS HANDLING						
	CIVIL / SITE WORK						
	Excavation (soil)	120	CY	15	1,800	1.00	1,800
	Structural Backfill	30	CY	40	1,200	1.00	1,200
	ARCHITECTURAL / STRUCTURAL						
	Solids Handling Building	16,991	SF	150	2,548,650	1.00	2,548,650
	PROCESS / MECHANICAL						
	Gravity Belt Thickeners	3	EA	237,149	711,448	1.00	711,448
	Thickened Sludge Pumps	4	EA	20,154	80,617	1.00	80,617
	Polymer System - Thickening	1	LS	188,730	188,730	1.00	188,730
	Dewatering Centrifuge	3	EA	771,131	2,313,392	1.00	2,313,392
	Classifiers, Hoppers, Conveyors	1	EA	750,000	750,000	1.00	750,000
	Centrifuge Feed Pumps	3	EA	20,154	60,463	1.00	60,463
	Misc. Mechanical (15% of equip)	0.15	LS	4,104,649	615,697	1.00	615,697
	HVAC / PLUMBING / FIRE PROTECTION						
	Solids Handling Building	16,991	SF	39	660,631	1.00	660,631
	ELECTRICAL / INSTRUMENTATION						
	Solids Handling Building	16,991	SF	32	550,526	1.00	550,526
	Misc. Electrical (20% of equip)	0.20	%	4,104,649	820,930	1.00	820,930
	Misc. I&C (15% of equip)	0.15	%	4,104,649	615,697	1.00	615,697
						SUBTOTAL	***$ 9,919,781***
14	ANAEROBIC DIGESTION						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	Anaerobic Digesters	1	LS	16,200,000	16,200,000	1.00	16,200,000
						SUBTOTAL	***$ 16,200,000***
15	ADMINISTRATION BUILDING						
	CIVIL / SITE WORK						
	Excavation (soil)	80	CY	15	1,200	1.00	1,200
	Structural Backfill	20	CY	40	800	1.00	800
	ARCHITECTURAL / STRUCTURAL						
	Building	7,200	SF	150	1,080,000	1.00	1,080,000
	PROCESS / MECHANICAL						
	Maintenance Specialty Items	1	LS	100,000	100,000	1.00	100,000
	HVAC / PLUMBING / FIRE PROTECTION						
	Admin Building	7,200	SF	39	279,945	1.00	279,945
	ELECTRICAL / INSTRUMENTATION						
	Admin Building	7,200	SF	32	233,288	1.00	233,288
	Misc. Electrical (20% of process)	0.20	%	100,000	20,000	1.00	20,000
	Misc. I&C (15% of process)	0.15	%	100,000	15,000	1.00	15,000
						SUBTOTAL	***$ 1,730,233***

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - BUILD OUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
16	**ODOR CONTROL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Primary Odor Control System (Headworks,	1	LS	705,277	705,277	1.00	705,277
	Solids Handling Odor Control System	1	LS	2,052,499	2,052,499	1.00	2,052,499
	Misc. Mechanical (15% of equip)	0.15	LS	2,757,775	413,666	1.00	413,666
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip.)	0.20	%	2,757,775	551,555	1.00	551,555
	Misc. I&C (15% of equip.)	0.15	%	2,757,775	413,666	1.00	413,666
						SUBTOTAL	***$ 4,136,663***
17	**MISCELLANEOUS ONSITE**						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	65,296,000	7,835,520	1.00	7,835,520
						SUBTOTAL	***$ 7,835,520***

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OPERATIONS AND MAINTENANCE COSTS ESTIMATE

BUILDOUT (9.6 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 15, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	DESCRIPTION	Total Cost
1	ANNUAL POWER COSTS	$1,734,000
2	ANNUAL CHEMICAL COSTS	$502,000
3	ANNUAL LABOR COSTS	$600,000
4	ANNUAL MISCELLANEOUS COSTS	$795,000
	ESTIMATED ANNUAL O&M TOTAL	**$3,631,000**
	PRESENT WORTH FACTOR	***13.74***
	O&M PRESENT WORTH COST TOTAL	**$49,878,643**

NOTES

1. Present worth factor annual interest rate = 6%
2. Present worth factor annual inflation rate = 2%
3. Present worth factor planning period (yrs) = 20

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 15, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	ANNUAL POWER COSTS					
	Headworks	590,261	kW-hr	0.10	59,000	$59,000
	Primary Treatment	291,510	kW-hr	0.10	29,200	$29,200
	Secondary Treatment	4,737,406	kW-hr	0.10	473,700	$473,700
	Tertiary Filtration	42,198	kW-hr	0.10	4,200	$4,200
	UV Disinfection System	1,815,948	kW-hr	0.10	181,600	$181,600
	Effluent Pumping System	435,493	kW-hr	0.10	43,500	$43,500
	Sludge Thickening	261,745	kW-hr	0.10	26,200	$26,200
	Sludge Digestion	2,219,618	kW-hr	0.10	222,000	$222,000
	Sludge Dewatering	1,308,027	kW-hr	0.10	130,800	$130,800
	Solids Handling Building	1,655,158	kW-hr	0.10	165,500	$165,500
	Odor Control	3,974,889	kW-hr	0.10	397,500	$397,500
			ANNUAL POWER COST SUBTOTAL			***$1,733,200***
2	ANNUAL CHEMICAL COSTS					
	Disk Filters	1	LS	-	5,000	$5,000
	Chemicals (Caustic, Sodium Hypochlorite, Ferrous Chloride)	1	LS	-	299,000	$299,000
	Emulsion Polymer, Active	90,520	lb	1.85	167,500	$167,500
	Hydrochloric Acid	1	LS	--	10,000	$10,000
	Diesel Fuel	1	LS	--	15,000	$15,000
	Oils and Lubricants	1	LS	--	5,000	$5,000
			ANNUAL CHEMICAL COST SUBTOTAL			***$501,500***
3	ANNUAL LABOR COSTS (including 32% for benefits)					
	Operators	6	staff	60,000	360,000	$360,000
	Mechanical	1	staff	65,000	65,000	$65,000
	Supervisor	1	staff	75,000	75,000	$75,000
	Electrical/Instrumentation	1	staff	65,000	65,000	$65,000
	Administration	1	staff	35,000	35,000	$35,000
			ANNUAL LABOR SUBTOTAL			***$600,000***
4	ANNUAL MISCELLANEOUS COSTS					
	Disk Filters - Maintenance	1	LS	-	13,700	$13,700
	Annual UV Lamp Replacement Cost	1	LS	-	163,800	$163,800
	Off-Site Sludge Disposal	14,308	wet ton	15.00	214,600	$214,600
	Off-Site Screenings/Grit Disposal	1	LS	--	5,000	$5,000
	General Parts and Supplies	1	LS	--	25,000	$25,000
	Communication Charges	12	months	1,300	15,600	$15,600
	Potable Water Charges	12	months	600	7,200	$7,200
	Major Process Parts Replacement	1	LS	--	150,000	$150,000
	Centrifuge Maintenance Services Contract	1	LS	--	50,000	$50,000
	Generator Maintenance Services Contract	1	LS	--	100,000	$100,000
	Miscellaneous	1	LS	--	50,000	$50,000
			ANNUAL MISCELLANEOUS COST SUBTOTAL			***$794,900***

CAPITAL COST ESTIMATE

BUILDOUT (9.6 MGD)

MEMBRANE (MBR) PROCESS TREATMENT ALTERNATIVE

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Estimate Class:	4
Job #:	8286A.00	PIC:	J. Doller
Location:	Prescott, Az	PM:	M. Courtney
Zip Code:	86301	Date:	June 17, 2010
		By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION		TOTAL
01	General Conditions		$11,209,000
02	Headworks/Screening		$1,574,000
03	Fine Screening and Grit Removal		$3,733,000
04	Splitter Boxes		$329,000
05	Aeration System		$9,321,000
06	Blower Building		$3,624,000
07	Membrane System		$20,524,000
08	Disinfection		$3,850,000
09	Effluent Pump Station		$429,000
10	Solids Handling		$9,920,000
11	Digesters		$7,543,000
12	Administration / Maintenance Building		$1,731,000
13	Odor Control		$4,137,000
14	Miscellaneous Onsite		$8,005,800
	TOTAL DIRECT COST		**$85,929,800**
	Contingency	20.0%	$17,185,960
		Subtotal	**$103,115,760**
	General Contractor Overhead, Profit & Risk	15.0%	$15,467,364
		Subtotal	**$118,583,124**
	Escalation to Mid-Point	0.0%	$0
		Subtotal	**$118,583,124**
	Sales Tax	5.0%	$5,929,156
		Subtotal	**$124,512,280**
	Bid Market Allowance	0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST		**$124,512,280**

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	GENERAL CONDITIONS	0.15	%	74,720,800	11,208,120	1.00	$11,208,120
					SUBTOTAL		***$11,208,120***
2	HEADWORKS/ COARSE SCREENING						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	$800
	Structural Backfill	13	CY	40	533	1.00	$533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	$150,400
	Headworks Building	3,200	SF	150	480,000	1.00	$480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	$48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	2	EA	190,821	381,642	1.00	$381,642
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	$61,800
	Misc. Mechanical (15% of equip)	0.15	%	443,442	66,516	1.00	$66,516
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	$124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	$103,683
	Misc. Electrical (20% of equip)	0.20	%	443,442	88,688	1.00	$88,688
	Misc. I&C (15% of equip)	0.15	%	443,442	66,516	1.00	$66,516
					SUBTOTAL		***$1,573,713***
3	FINE SCREENING AND GRIT REMOVAL						
	CIVIL / SITE WORK						
	Excavation (soil)	69	CY	15	1,033	1.00	$1,033
	Structural Backfill	17	CY	40	689	1.00	$689
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	188	CY	800	150,400	1.00	$150,400
	Fine Screening - Building	5,720	SF	150	858,000	1.00	$858,000
	PROCESS / MECHANICAL						
	Vortex Grit System	2	EA	242,486	484,972	1.00	$484,972
	Fine Screens and Compactor	3	EA	352,713	1,058,140	1.00	$1,058,140
	Misc. Mechanical (15% of equip)	0.15	%	1,543,113	231,467	1.00	$231,467
	HVAC / PLUMBING / FIRE PROTECTION						
	Fine Screening - Building	5,720	SF	39	222,401	1.00	$222,401
	ELECTRICAL / INSTRUMENTATION						
	Fine Screening - Building	5,720	SF	32	185,334	1.00	$185,334
	Misc. Electrical (20% of equip)	0.20	%	1,543,113	308,623	1.00	$308,623
	Misc. I&C (15% of equip)	0.15	%	1,543,113	231,467	1.00	$231,467
					SUBTOTAL		***$3,732,526***

Carollo

MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
4	**SPLITTER BOX**						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	$26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	$23,150
	Structural Backfill	46	CY	40	1,852	1.00	$1,852
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	200	CY	800	160,000	1.00	$160,000
	Misc. Metals	2	LS	15,902	31,804	1.00	$31,804
	Misc. FRP Weirs	80	LF	90	7,216	1.00	$7,216
	PROCESS / MECHANICAL						
	Stainless Steel Gates	6	EA	8,589	51,534	1.00	$51,534
	Misc. Mechanical (15% of equip)	0.15	%	51,534	7,730	1.00	$7,730
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	51,534	10,307	1.00	$10,307
	Misc. I&C (15% of equip)	0.15	%	51,534	7,730	1.00	$7,730
						SUBTOTAL	***$328,062***
5	**AERATION SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	80,229	CY	15	1,203,430	1.00	$1,203,430
	Backfill (soil)	26,891	CY	20	537,821	1.00	$537,821
	Structural Backfill	4445	CY	40	177,792	1.00	$177,792
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	6,340	CY	600	3,804,000	1.00	$3,804,000
	Aluminum Flat Covers	60,000	SF	25	1,479,000	1.00	$1,479,000
	Misc - Handrails	2,000	LF	61	122,440	1.00	$122,440
	Misc - Stairs	30	RSR	375	11,251	1.00	$11,251
	PROCESS / MECHANICAL						
	Submersible Mixers	12	EA	19,624	235,489	1.00	$235,489
	Fine Bubble Diffuser System	6	LS	181,326	1,087,953	1.00	$1,087,953
	Misc. Mechanical (15% of equip)	0.15	%	1,323,442	198,516	1.00	$198,516
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,323,442	264,688	1.00	$264,688
	Misc. I&C (15% of equip)	0.15	%	1,323,442	198,516	1.00	$198,516
						SUBTOTAL	***$9,320,897***
6	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	40	CY	15	600	1.00	$600
	Structural Backfill	10	CY	40	400	1.00	$400
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,800	SF	150	270,000	1.00	$270,000

MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	5	EA	429,940	2,149,701	1.00	$2,149,701
	Misc. Mechanical (15% of equip)	0.15	%	2,149,701	322,455	1.00	$322,455
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,800	SF	39	69,986	1.00	$69,986
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,800	SF	32	58,322	1.00	$58,322
	Misc. Electrical (20% of equip)	0.20	%	2,149,701	429,940	1.00	$429,940
	Misc. I&C (15% of equip)	0.15	%	2,149,701	322,455	1.00	$322,455
						SUBTOTAL	***$3,623,860***
7	**MEMBRANE SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	142	CY	15	2,134	1.00	$2,134
	Structural Backfill	36	CY	40	1,422	1.00	$1,422
	ARCHITECTURAL / STRUCTURAL						
	Membrane Building	24,700	SF	150	3,705,000	1.00	$3,705,000
	Membrane Basins - Concrete	1,882	CY	600	1,129,200	1.00	$1,129,200
	PROCESS / MECHANICAL						
	Membrane Equipment	7	EA	1,685,714	11,800,000	1.00	$11,800,000
	Multi-Stage Cent. Blowers	8	EA	118,231	945,848	1.00	$945,848
	RAS Pumps	7	EA	60,000	420,000	1.00	$420,000
	WAS Pumps	3	EA	17,058	51,175	1.00	$51,175
	Misc. Mechanical (15% of equip)	0.15	%	1,417,023	212,553	1.00	$212,553
	HVAC / PLUMBING / FIRE PROTECTION						
	Membrane Building	24,700	SF	39	960,367	1.00	$960,367
	ELECTRICAL / INSTRUMENTATION						
	Membrane Building	24,700	SF	32	800,306	1.00	$800,306
	Misc. Electrical (20% of equip)	0.20	%	1,417,023	283,405	1.00	$283,405
	Misc. I&C (15% of equip)	0.15	%	1,417,023	212,553	1.00	$212,553
						SUBTOTAL	***$20,523,963***
8	**DISINFECTION**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	$0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	$0
	PROCESS / MECHANICAL						
	UV Equipment	7	LS	366,667	2,566,667	1.00	$2,566,667
	Misc. Mechanical (15% of equip)	0.15	LS	2,566,667	385,000	1.00	$385,000
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,566,667	513,333	1.00	$513,333
	Misc. I&C (15% of equip)	0.15	%	2,566,667	385,000	1.00	$385,000
						SUBTOTAL	***$3,850,000***
9	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	Excavation (soil)	2,621	CY	15	39,309	1.00	$39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	$32,410
	Structural Backfill	74	CY	40	2,963	1.00	$2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	$96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	$15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	5	EA	32,342	161,711	1.00	$161,711
	Misc. Mechanical (15% of equip)	0.15	%	161,711	24,257	1.00	$24,257
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	161,711	32,342	1.00	$32,342
	Misc. I&C (15% of equip)	0.15	%	161,711	24,257	1.00	$24,257
						SUBTOTAL	***$428,249***
10	**SOLIDS HANDLING**						
	CIVIL / SITE WORK						
	Excavation (soil)	120	CY	15	1,800	1.00	$1,800
	Structural Backfill	30	CY	40	1,200	1.00	$1,200
	ARCHITECTURAL / STRUCTURAL						
	Solids Handling Building	16,991	SF	150	2,548,650	1.00	$2,548,650
	PROCESS / MECHANICAL						
	Gravity Belt Thickeners	3	EA	237,149	711,448	1.00	$711,448
	Thickened Sludge Pumps	4	EA	20,154	80,617	1.00	$80,617
	Polymer System - Thickening	1	LS	188,730	188,730	1.00	$188,730
	Dewatering Centrifuge	3	EA	771,131	2,313,392	1.00	$2,313,392
	Conveyors	1	EA	750,000	750,000	1.00	$750,000
	Centrifuge Feed Pumps	3	EA	20,154	60,463	1.00	$60,463
	Misc. Mechanical (15% of equip)	0.15	LS	4,104,649	615,697	1.00	$615,697
	HVAC / PLUMBING / FIRE PROTECTION						
	Solids Handling Building	16,991	SF	39	660,631	1.00	$660,631
	ELECTRICAL / INSTRUMENTATION						
	Solids Handling Building	16,991	SF	32	550,526	1.00	$550,526
	Misc. Electrical (20% of equip)	0.20	%	4,104,649	820,930	1.00	$820,930
	Misc. I&C (15% of equip)	0.15	%	4,104,649	615,697	1.00	$615,697
						SUBTOTAL	***$9,919,781***

MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
11	AEROBIC DIGESTION						
	CIVIL / SITE WORK						
	Excavation (soil)	66,966	CY	15	1,004,497	1.00	$1,004,497
	Backfill (soil)	23,613	CY	20	472,260	1.00	$472,260
	Structural Backfill	3,211	CY	40	128,455	1.00	$128,455
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Digesters	4,000	CY	550	2,200,000	1.00	$2,200,000
	Building - Digester Blowers	7,225	SF	150	1,083,750	1.00	$1,083,750
	Blower Sound Enclosure	6	EA	28,500	171,000	1.00	$171,000
	Blower Silencer, 304L st stl	6	EA	16,850	101,100	1.00	$101,100
	PROCESS / MECHANICAL						
	Rotary Lobe Blower	6	EA	128,478	770,869	1.00	$770,869
	Diffusers	1	LS	473,568	473,568	1.00	$473,568
	Misc. Mechanical (15% of equip)	0.15	LS	1,244,437	186,666	1.00	$186,666
	HVAC / PLUMBING / FIRE PROTECTION						
	Building - Digester Blowers	7,225	SF	39	280,917	1.00	$280,917
	ELECTRICAL / INSTRUMENTATION						
	Building - Digester Blowers	7,225	SF	32	234,098	1.00	$234,098
	Misc. Electrical (20% of equip)	0.20	%	1,244,437	248,887	1.00	$248,887
	Misc. I&C (15% of equip)	0.15	%	1,244,437	186,666	1.00	$186,666
					SUBTOTAL		***$7,542,732***
12	ADMINISTRATION BUILDING						
	CIVIL / SITE WORK						
	Excavation (soil)	80	CY	15	1,200	1.00	$1,200
	Structural Backfill	20	CY	40	800	1.00	$800
	ARCHITECTURAL / STRUCTURAL						
	Building	7,200	SF	150	1,080,000	1.00	$1,080,000
	PROCESS / MECHANICAL						
	Maintenance Specialty Items	1	LS	100,000	100,000	1.00	$100,000
	HVAC / PLUMBING / FIRE PROTECTION						
	Admin Building	7,200	SF	39	279,945	1.00	$279,945
	ELECTRICAL / INSTRUMENTATION						
	Admin Building	7,200	SF	32	233,288	1.00	$233,288
	Misc. Electrical (20% of process)	0.20	%	100,000	20,000	1.00	$20,000
	Misc. I&C (15% of process)	0.15	%	100,000	15,000	1.00	$15,000
					SUBTOTAL		***$1,730,233***

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - BUILDOUT (9.6 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
13	ODOR CONTROL						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	$0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	$0
	PROCESS / MECHANICAL						
	Primary Odor Control System	1	LS	705,277	705,277	1.00	$705,277
	Solids Handling Odor Control System	1	LS	2,052,499	2,052,499	1.00	$2,052,499
	Misc. Mechanical (15% of equip)	0.15	LS	2,757,775	413,666	1.00	$413,666
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of process)	0.20	%	2,757,775	551,555	1.00	$551,555
	Misc. I&C (15% of process)	0.15	%	2,757,775	413,666	1.00	$413,666
						SUBTOTAL	***$4,136,663***
14	MISCELLANEOUS ONSITE						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	66,715,000	8,005,800	1.00	$8,005,800
						SUBTOTAL	***$8,005,800***

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OPERATIONS AND MAINTENANCE COSTS ESTIMATE

BUILDOUT (9.6 MGD)

MEMBRANE (MBR) PROCESS TREATMENT ALTERNATIVE

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 15, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	DESCRIPTION	Total Cost
1	ANNUAL POWER COSTS	$2,230,000
2	ANNUAL CHEMICAL COSTS	$558,000
3	ANNUAL LABOR COSTS	$730,000
4	ANNUAL MISCELLANEOUS COSTS	$1,342,000
	ESTIMATED ANNUAL O&M TOTAL	**$4,860,000**
	PRESENT WORTH FACTOR	***13.74***
	O&M PRESENT WORTH COST TOTAL	**$66,761,279**

NOTES

1. Present worth factor annual interest rate = 6%
2. Present worth factor annual inflation rate = 2%
3. Present worth factor planning period (yrs) = 20

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MBR TREATMENT ALTERNATIVE - OPERATION AND MAINTENANCE COSTS
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 15, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**ANNUAL POWER COSTS**					
	Headworks	502,073	kW-hr	0.10	50,200	$50,200
	Fine Screening and Grit Removal	638,922	kW-hr	0.10	63,900	$63,900
	Secondary Treatment	11,498,404	kW-hr	0.10	1,149,800	$1,149,800
	UV Disinfection System	738,468	kW-hr	0.10	73,800	$73,800
	Effluent Pumping System	435,493	kW-hr	0.10	43,500	$43,500
	Sludge Thickening	348,993	kW-hr	0.10	34,900	$34,900
	Sludge Digestion	1,019,060	kW-hr	0.10	101,900	$101,900
	Sludge Dewatering	817,517	kW-hr	0.10	81,800	$81,800
	Solids Handling Building	1,655,158	kW-hr	0.10	165,500	$165,500
	Administration Building	668,563	kW-hr	0.10	66,900	$66,900
	Odor Control	3,974,889	kW-hr	0.10	397,500	$397,500
					ANNUAL POWER COST SUBTOTAL	***$2,229,700***
2	**ANNUAL CHEMICAL COSTS**					
	Membranes Chemicals	1	LS	-	86,400	$86,400
	Chemicals (Caustic, Sodium Hypochlorite, Ferrous Chloride)	1	LS	-	299,000	$299,000
	Emulsion Polymer, Active	76,650	lb	1.85	141,800	$141,800
	Hydrochloric Acid	1	LS	--	10,000	$10,000
	Diesel Fuel	1	LS	--	15,000	$15,000
	Oils and Lubricants	1	LS	--	5,000	$5,000
					ANNUAL CHEMICAL COST SUBTOTAL	***$557,200***
3	**ANNUAL LABOR COSTS (including 32% for benefits)**					
	Operators	6	staff	60,000	360,000	$360,000
	Mechanical	2	staff	65,000	130,000	$130,000
	Supervisor	1	staff	75,000	75,000	$75,000
	Electrical/Instrumentation	2	staff	65,000	130,000	$130,000
	Administration	1	staff	35,000	35,000	$35,000
					ANNUAL LABOR SUBTOTAL	***$730,000***
4	**ANNUAL MISCELLANEOUS COSTS**					
	Annual UV Lamp Replacement Cost	1	LS	-	163,800	$163,800
	Membrane Replacement Cost	1	LS	-	443,500	$443,500
	Off-Site Sludge Disposal	12,082	wet ton	15.00	181,200	$181,200
	Off-Site Screenings/Grit Disposal	1	LS	--	5,000	$5,000
	General Parts and Supplies	1	LS	--	25,000	$25,000
	Communication Charges	12	months	1,300	15,600	$15,600
	Potable Water Charges	12	months	600	7,200	$7,200
	Major Process Parts Replacement	1	LS	--	300,000	$300,000
	Centrifuge Maintenance Services Contract	1	LS	--	50,000	$50,000
	Generator Maintenance Services Contract	1	LS	--	100,000	$100,000
	Miscellaneous	1	LS	--	50,000	$50,000
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$1,341,300***

CAPITAL COST ESTIMATE

PHASE 1 (3.2 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

		Estimate Class:	4
Project:	Prescott Airport and Sundog WRF Technology Assessments	PIC:	J. Doller
Job #:	8286A.00	PM:	M. Courtney
Location:	Prescott, Az	Date:	June 17, 2010
Zip Code:	86301	By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION			TOTAL
01	General Conditions			$2,738,000
02	Headworks/Screening			$1,287,000
03	Grit Removal			$489,000
04	Splitter Boxes			$354,000
05	Primary Clarification			$0
06	Aeration System			$4,629,000
07	Blower Building			$894,000
08	Secondary Clarification			$3,426,000
09	RAS/WAS Pump Station			$378,000
10	Tertiary Filtration			$1,906,000
11	Disinfection			$1,775,000
12	Effluent Pump Station			$283,000
13	Solids Handling			$523,000
14	Anaerobic Digesters			$0
15	Administration / Maintenance Building			$0
16	Odor Control			$353,000
17	Miscellaneous Onsite			$1,956,000
		TOTAL DIRECT COST		**$20,991,000**
	Contingency		20.0%	$4,198,200
		Subtotal		**$25,189,200**
	General Contractor Overhead, Profit & Risk		15.0%	$3,778,380
		Subtotal		**$28,967,580**
	Escalation to Mid-Point		0.0%	$0
		Subtotal		**$28,967,580**
	Sales Tax		5.0%	$1,448,379
		Subtotal		**$30,415,959**
	Bid Market Allowance		0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST			**$30,415,959**

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	**GENERAL CONDITIONS**	0.15	%	18,253,000	2,737,950	1.00	2,737,950
						SUBTOTAL	***$ 2,737,950***
2	**HEADWORKS/ SCREENING**						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	800
	Structural Backfill	13	CY	40	533	1.00	533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	150,400
	Headworks Building	3,200	SF	150	480,000	1.00	480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	1	EA	190,821	190,821	1.00	190,821
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	61,800
	Misc. Mechanical (15% of equip)	0.15	%	252,621	37,893	1.00	37,893
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	103,683
	Misc. Electrical (20% of equip)	0.20	%	252,621	50,524	1.00	50,524
	Misc. I&C (15% of equip)	0.15	%	252,621	37,893	1.00	37,893
						SUBTOTAL	***$ 1,287,481***
3	**GRIT REMOVAL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	94	CY	800	75,200	1.00	75,200
	Misc. Metals, Wood & Plastics, Finishes,	1	LS	49,763	49,763	1.00	49,763
	PROCESS / MECHANICAL						
	Vortex Grit System	1	EA	242,486	242,486	1.00	242,486
	Misc. Mechanical (15% of equip)	0.15	%	242,486	36,373	1.00	36,373
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	242,486	48,497	1.00	48,497
	Misc. I&C (15% of equip)	0.15	%	242,486	36,373	1.00	36,373
						SUBTOTAL	***$ 488,692***

Carollo

CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
4	SPLITTER BOX						
	CIVIL / SITE WORK						
	Excavation (soil)	3,565	CY	15	53,477	1.00	53,477
	Backfill (soil)	2,315	CY	20	46,300	1.00	46,300
	Structural Backfill	93	CY	40	3,704	1.00	3,704
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	200	CY	800	160,000	1.00	160,000
	Misc. Metals	2	LS	15,902	31,804	1.00	31,804
	Misc. FRP Weirs	80	LF	90	7,216	1.00	7,216
	PROCESS / MECHANICAL						
	Stainless Steel Gates	4	EA	8,589	34,356	1.00	34,356
	Misc. Mechanical (15% of equip)	0.15	%	34,356	5,153	1.00	5,153
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	34,356	6,871	1.00	6,871
	Misc. I&C (15% of equip)	0.15	%	34,356	5,153	1.00	5,153
						SUBTOTAL	***$ 354,035***
5	PRIMARY CLARIFICATION						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	***$ -***
6	AERATION SYSTEM						
	CIVIL / SITE WORK						
	Excavation (soil)	46,473	CY	15	697,089	1.00	697,089
	Backfill (soil)	8,825	CY	20	176,503	1.00	176,503
	Structural Backfill	3,585	CY	40	143,419	1.00	143,419
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	4,509	CY	600	2,705,156	1.00	2,705,156
	PROCESS / MECHANICAL						
	Submersible Mixers	4	EA	29,624	118,496	1.00	118,496
	MLR Pumps	4	EA	30,812	123,248	1.00	123,248
	Fine Bubble Diffuser System	2	LS	181,326	362,651	1.00	362,651
	Misc. Mechanical (15% of equip)	0.15	LS	604,395	90,659	1.00	90,659
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	604,395	120,879	1.00	120,879
	Misc. I&C (15% of equip)	0.15	%	604,395	90,659	1.00	90,659
						SUBTOTAL	***$ 4,628,760***

Carollo CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
7	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	31	CY	15	467	1.00	467
	Structural Backfill	8	CY	40	311	1.00	311
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,200	SF	150	180,000	1.00	180,000
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	3	EA	139,398	418,195	1.00	418,195
	Misc. Mechanical (15% of equip)	0.15	%	418,195	62,729	1.00	62,729
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,200	SF	39	46,658	1.00	46,658
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,200	SF	32	38,881	1.00	38,881
	Misc. Electrical (20% of equip)	0.20	%	418,195	83,639	1.00	83,639
	Misc. I&C (15% of equip)	0.15	%	418,195	62,729	1.00	62,729
						SUBTOTAL	***$ 893,608***
8	**SECONDARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	18,727	CY	15	280,898	1.00	280,898
	Backfill (soil)	5,926	CY	20	118,528	1.00	118,528
	Structural Backfill	1,164	CY	40	46,546	1.00	46,546
	ARCHITECTURAL / STRUCTURAL						
	Secondary Clarifiers - Concrete	2,050	CY	800	1,640,000	1.00	1,640,000
	Misc. FRP Baffles and Weirs	2	EA	25,000	50,000	1.00	50,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	2	EA	430,000	860,000	1.00	860,000
	Misc. Mechanical (15% of equip)	0.15	%	860,000	129,000	1.00	129,000
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	860,000	172,000	1.00	172,000
	Misc. I&C (15% of equip)	0.15	%	860,000	129,000	1.00	129,000
						SUBTOTAL	***$ 3,425,971***
9	**RAS WAS PUMP STATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	23,150
	Structural Backfill	46	CY	40	1,852	1.00	1,852
	ARCHITECTURAL / STRUCTURAL						
	RAS P. S. - Slab/Footing	35	CY	580	20,300	1.00	20,300
	RAS P. S. - Walls	116	CY	710	82,360	1.00	82,360
	RAS P. S. - Elevated Slab	35	CY	840	29,169	1.00	29,169
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	RAS Pumps	2	EA	40,740	81,480	1.00	81,480
	WAS Pumps	2	EA	11,940	23,880	1.00	23,880
	Scum Pumps	2	EA	7,000	14,000	1.00	14,000
	Misc. Mechanical (15% of equip)	0.15	LS	119,360	17,904	1.00	17,904
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	119,360	23,872	1.00	23,872
	Misc. I&C (15% of equip)	0.15	%	119,360	17,904	1.00	17,904
						SUBTOTAL	***$ 377,609***
10	**TERTIARY FILTRATION**						
	CIVIL / SITE WORK						
	Excavation and backfill	1	LS	160,221	160,221	1.00	160,221
	ARCHITECTURAL / STRUCTURAL						
	Filter basins and channels - walls	213	CY	830	177,159	1.00	177,159
	Filter basins and channels - slabs	153	CY	520	79,733	1.00	79,733
	Misc - Metals	1	LS	116,277	116,277	1.00	116,277
	PROCESS / MECHANICAL						
	Disk Filters Equipment	1	LS	727,501	727,501	1.00	727,501
	Chemical feed	1	LS	82,056	82,056	1.00	82,056
	Filter Inlet gates	3	EA	8,002	24,006	1.00	24,006
	Channel gates	3	EA	15,450	46,350	1.00	46,350
	Effluent weir gate	1	EA	16,450	16,450	1.00	16,450
	Sump pump	1	EA	18,616	18,616	1.00	18,616
	Misc. Mechanical (15% of equip)	0.15	%	914,979	137,247	1.00	137,247
	HVAC / PLUMBING / FIRE PROTECTION						
	None		--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	914,979	182,996	1.00	182,996
	Misc. I&C (15% of equip)	0.15	%	914,979	137,247	1.00	137,247
						SUBTOTAL	***$ 1,905,859***
11	**DISINFECTION**						
	CIVIL / SITE WORK						
	Excavation (soil)	162	CY	15	2,432	1.00	2,432
	Backfill (soil)	66	CY	20	1,322	1.00	1,322
	Structural Backfill	27	CY	40	1,067	1.00	1,067
	ARCHITECTURAL / STRUCTURAL						
	UV Channels - Slab/Footing	13	CY	580	7,734	1.00	7,734
	UV Channels - Walls	53	CY	710	37,743	1.00	37,743
	PROCESS / MECHANICAL						
	UV Equipment	4	LS	287,500	1,150,000	1.00	1,150,000
	Misc. Mechanical (15% of equip)	0.15	LS	1,150,000	172,500	1.00	172,500

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Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,150,000	230,000	1.00	230,000
	Misc. I&C (15% of equip)	0.15	%	1,150,000	172,500	1.00	172,500
						SUBTOTAL	***$ 1,775,298***
12	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	32,410
	Structural Backfill	74	CY	40	2,963	1.00	2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	2	EA	32,342	64,685	1.00	64,685
	Misc. Mechanical (15% of equip)	0.15	LS	64,685	9,703	1.00	9,703
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	64,685	12,937	1.00	12,937
	Misc. I&C (15% of equip)	0.15	%	64,685	9,703	1.00	9,703
						SUBTOTAL	***$ 282,709***
13	**SOLIDS HANDLING**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Dewatering Centrifuge Package	1	EA	348,445	348,445	1.00	348,445
	Misc. Mechanical (15% of equip)	0.15	%	348,445	52,267	1.00	52,267
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	348,445	69,689	1.00	69,689
	Misc. I&C (15% of equip)	0.15	%	348,445	52,267	1.00	52,267
						SUBTOTAL	***$ 522,668***
14	**ANAEROBIC DIGESTION**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	***$ -***
15	**ADMINISTRATION BUILDING**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	***$ -***

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CONVENTIONAL (MLE) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
16	**ODOR CONTROL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Primary Odor Control System (Headworks,	1	LS	235,092	235,092	1.00	235,092
	Misc. Mechanical (15% of equip)	0.15	LS	235,092	35,264	1.00	35,264
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip.)	0.20	%	235,092	47,018	1.00	47,018
	Misc. I&C (15% of equip.)	0.15	%	235,092	35,264	1.00	35,264
						SUBTOTAL	***$ 352,638***
17	**MISCELLANEOUS ONSITE**						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	16,297,000	1,955,640	1.00	1,955,640
						SUBTOTAL	***$ 1,955,640***

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

CAPITAL COST ESTIMATE

PHASE 1 (3.2 MGD)

MEMBRANE (MBR) PROCESS TREATMENT ALTERNATIVE

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Estimate Class:	4
Job #:	8286A.00	PIC:	J. Doller
Location:	Prescott, Az	PM:	M. Courtney
Zip Code:	86301	Date:	June 17, 2010
		By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION		TOTAL
01	General Conditions		$4,345,000
02	Headworks/Screening		$1,259,000
03	Fine Screening and Grit Removal		$2,765,000
04	Splitter Boxes		$277,000
05	Aeration System		$3,123,000
06	Blower Building		$2,201,000
07	Membrane System		$12,131,000
08	Disinfection		$1,650,000
09	Effluent Pump Station		$283,000
10	Solids Handling		$523,000
11	Digesters		$595,000
12	Administration / Maintenance Building		$0
13	Odor Control		$1,058,000
14	Miscellaneous Onsite		$3,104,000
	TOTAL DIRECT COST		**$33,314,000**
	Contingency	20.0%	$6,662,800
		Subtotal	**$39,976,800**
	General Contractor Overhead, Profit & Risk	15.0%	$5,996,520
		Subtotal	**$45,973,320**
	Escalation to Mid-Point	0.0%	$0
		Subtotal	**$45,973,320**
	Sales Tax	5.0%	$2,298,666
		Subtotal	**$48,271,986**
	Bid Market Allowance	0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST		**$48,271,986**

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	GENERAL CONDITIONS	0.15	%	28,969,000	4,345,350	1.00	$4,345,350
					SUBTOTAL		$4,345,350
2	HEADWORKS/ COARSE SCREENING						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	$800
	Structural Backfill	13	CY	40	533	1.00	$533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	$150,400
	Headworks Building	3,200	SF	150	480,000	1.00	$480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	$48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	1	EA	190,821	190,821	1.00	$190,821
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	$61,800
	Misc. Mechanical (15% of equip)	0.15	%	252,621	9,541	1.00	$9,541
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	$124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	$103,683
	Misc. Electrical (20% of equip)	0.20	%	252,621	50,524	1.00	$50,524
	Misc. I&C (15% of equip)	0.15	%	252,621	37,893	1.00	$37,893
					SUBTOTAL		$1,259,129
3	FINE SCREENING AND GRIT REMOVAL						
	CIVIL / SITE WORK						
	Excavation (soil)	69	CY	15	1,033	1.00	$1,033
	Structural Backfill	17	CY	40	689	1.00	$689
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	94	CY	800	75,200	1.00	$75,200
	Fine Screening - Building	5,720	SF	150	858,000	1.00	$858,000
	PROCESS / MECHANICAL						
	Vortex Grit System	1	EA	242,486	242,486	1.00	$242,486
	Fine Screens and Compactor	2	EA	352,713	705,427	1.00	$705,427
	Misc. Mechanical (15% of equip)	0.15	%	947,913	142,187	1.00	$142,187
	HVAC / PLUMBING / FIRE PROTECTION						
	Fine Screening - Building	5,720	SF	39	222,401	1.00	$222,401
	ELECTRICAL / INSTRUMENTATION						
	Fine Screening - Building	5,720	SF	32	185,334	1.00	$185,334
	Misc. Electrical (20% of equip)	0.20	%	947,913	189,583	1.00	$189,583
	Misc. I&C (15% of equip)	0.15	%	947,913	142,187	1.00	$142,187
					SUBTOTAL		$2,764,527

MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

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Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
4	**SPLITTER BOX**						
	CIVIL / SITE WORK						
	Excavation (soil)	1783	CY	15	26,738	1.00	$26,738
	Backfill (soil)	1158	CY	20	23,150	1.00	$23,150
	Structural Backfill	46	CY	40	1,852	1.00	$1,852
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	200	CY	800	160,000	1.00	$160,000
	Misc. Metals	2	LS	15,902	31,804	1.00	$31,804
	Misc. FRP Weirs	80	LF	90	7,216	1.00	$7,216
	PROCESS / MECHANICAL						
	Stainless Steel Gates	2	EA	8,589	17,178	1.00	$17,178
	Misc. Mechanical (15% of equip)	0.15	%	17,178	2,577	1.00	$2,577
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	17,178	3,436	1.00	$3,436
	Misc. I&C (15% of equip)	0.15	%	17,178	2,577	1.00	$2,577
						SUBTOTAL	***$276,527***
5	**AERATION SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	26,743	CY	15	401,143	1.00	$401,143
	Backfill (soil)	8,964	CY	20	179,274	1.00	$179,274
	Structural Backfill	1482	CY	40	59,264	1.00	$59,264
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	2,113	CY	600	1,268,000	1.00	$1,268,000
	Aluminum Flat Covers	20,000	SF	25	493,000	1.00	$493,000
	Misc - Handrails	800	LF	61	48,976	1.00	$48,976
	Misc - Stairs	30	RSR	375	11,251	1.00	$11,251
	PROCESS / MECHANICAL						
	Submersible Mixers	4	EA	19,624	78,496	1.00	$78,496
	Fine Bubble Diffuser System	2	LS	181,326	362,651	1.00	$362,651
	Misc. Mechanical (15% of equip)	0.15	%	441,147	66,172	1.00	$66,172
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	441,147	88,229	1.00	$88,229
	Misc. I&C (15% of equip)	0.15	%	441,147	66,172	1.00	$66,172
						SUBTOTAL	***$3,122,629***
6	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	31	CY	15	467	1.00	$467
	Structural Backfill	8	CY	40	311	1.00	$311
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,200	SF	150	180,000	1.00	$180,000

MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

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Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	3	EA	429,940	1,289,821	1.00	$1,289,821
	Misc. Mechanical (15% of equip)	0.15	%	1,289,821	193,473	1.00	$193,473
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,200	SF	39	46,658	1.00	$46,658
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,200	SF	32	38,881	1.00	$38,881
	Misc. Electrical (20% of equip)	0.20	%	1,289,821	257,964	1.00	$257,964
	Misc. I&C (15% of equip)	0.15	%	1,289,821	193,473	1.00	$193,473
						SUBTOTAL	**$2,201,048**
7	**MEMBRANE SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	142	CY	15	2,134	1.00	$2,134
	Structural Backfill	36	CY	40	1,422	1.00	$1,422
	ARCHITECTURAL / STRUCTURAL						
	Membrane Building	24,700	SF	150	3,705,000	1.00	$3,705,000
	Membrane Basins - Concrete	807	CY	600	483,943	1.00	$483,943
	PROCESS / MECHANICAL						
	Membrane Equipment	3	EA	1,685,714	5,057,143	1.00	$5,057,143
	Multi-Stage Cent. Blowers	4	EA	118,231	472,924	1.00	$472,924
	RAS Pumps	4	EA	60,000	240,000	1.00	$240,000
	WAS Pumps	2	EA	17,058	34,117	1.00	$34,117
	Misc. Mechanical (15% of equip)	0.15	%	747,041	112,056	1.00	$112,056
	HVAC / PLUMBING / FIRE PROTECTION						
	Membrane Building	24,700	SF	39	960,367	1.00	$960,367
	ELECTRICAL / INSTRUMENTATION						
	Membrane Building	24,700	SF	32	800,306	1.00	$800,306
	Misc. Electrical (20% of equip)	0.20	%	747,041	149,408	1.00	$149,408
	Misc. I&C (15% of equip)	0.15	%	747,041	112,056	1.00	$112,056
						SUBTOTAL	**$12,130,875**
8	**DISINFECTION**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	$0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	$0
	PROCESS / MECHANICAL						
	UV Equipment	3	LS	366,667	1,100,000	1.00	$1,100,000
	Misc. Mechanical (15% of equip)	0.15	LS	1,100,000	165,000	1.00	$165,000
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,100,000	220,000	1.00	$220,000
	Misc. I&C (15% of equip)	0.15	%	1,100,000	165,000	1.00	$165,000
						SUBTOTAL	**$1,650,000**
9	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	$39,309

carollo

MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	Backfill (soil)	1,621	CY	20	32,410	1.00	$32,410
	Structural Backfill	74	CY	40	2,963	1.00	$2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	$96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	$15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	2	EA	32,342	64,685	1.00	$64,685
	Misc. Mechanical (15% of equip)	0.15	%	64,685	9,703	1.00	$9,703
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	64,685	12,937	1.00	$12,937
	Misc. I&C (15% of equip)	0.15	%	64,685	9,703	1.00	$9,703
						SUBTOTAL	***$282,709***
10	**SOLIDS HANDLING**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Dewatering Centrifuge Package	1	EA	348,445	348,445	1.00	$348,445
	Misc. Mechanical (15% of equip)	0.15	LS	348,445	52,267	1.00	$52,267
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	348,445	69,689	1.00	$69,689
	Misc. I&C (15% of equip)	0.15	%	348,445	52,267	1.00	$52,267
						SUBTOTAL	***$522,668***
11	**AEROBIC DIGESTION**						
	ARCHITECTURAL / STRUCTURAL						
	Blower Sound Enclosure	2	EA	28,500	57,000	1.00	$57,000
	Blower Silencer, 304L st stl	2	EA	16,850	33,700	1.00	$33,700
	PROCESS / MECHANICAL						
	Rotary Lobe Blower	2	EA	128,478	256,956	1.00	$256,956
	Diffusers	1	LS	78,928	78,928	1.00	$78,928
	Misc. Mechanical (15% of equip)	0.15	LS	335,884	50,383	1.00	$50,383
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	335,884	67,177	1.00	$67,177
	Misc. I&C (15% of equip)	0.15	%	335,884	50,383	1.00	$50,383
						SUBTOTAL	***$594,526***

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MEMBRANE (MBR) TREATMENT ALTERNATIVE - PHASE 1 (3.2 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
12	**ODOR CONTROL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	$0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	$0
	PROCESS / MECHANICAL						
	Primary Odor Control System	1	LS	705,277	705,277	1.00	$705,277
	Misc. Mechanical (15% of equip)	0.15	LS	705,277	105,791	1.00	$105,791
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip.)	0.20	%	705,277	141,055	1.00	$141,055
	Misc. I&C (15% of equip.)	0.15	%	705,277	105,791	1.00	$105,791
						SUBTOTAL	***$1,057,915***
13	**MISCELLANEOUS ONSITE**						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	25,865,000	3,103,800	1.00	$3,103,800
						SUBTOTAL	***$3,103,800***

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 6
Airport WRF Centralized Treatment
Feasibility Analysis

Final

In Association with

Project No. 164890

3133 E. Camelback Rd • Suite 210 • PHOENIX, ARIZONA 85016 • (602) 381-4400 • FAX (602) 381-4440

City of Prescott

TECHNICAL MEMORANDUM
NO. 6
AIRPORT WRF CENTRALIZED TREATMENT
FEASIBILITY ANALYSIS

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ES6 TM 6 – AIRPORT WRF CENTRALIZED TREATMENT FEASIBILITY ANALYSIS

ES6.1 Introduction

TM 5S and TM 5A presented recommendations for improvements at the Sundog WWTP and Airport WRF based on both plants maintaining treatment for its respective collection system tributary areas. This TM 6 considers discontinuing treatment at the Sundog WWTP, conveying all wastewater to the Airport WRF and centralizing treatment at the Airport WRF.

ES6.2 Existing Facilities

The existing treatment facilities at the Sundog WWTP and Airport WRF were described in detail in TM 3S and TM 3A respectively.

ES6.3 Reclaimed Water Pipeline Rehabilitation Alternatives

An 18" / 24" pipeline conveys reclaimed water from the Sundog WWTP to the aquifer recharge basins near the Airport WRF. Converting the Sundog reclaimed water pipeline for conveyance of raw wastewater would require rehabilitation for corrosion protection. Epoxy lining could be used to provide corrosion protection, however that approach would provide no structural integrity and would required periodic inspection and maintenance. Since the pipeline has not been inspected for 20 years due to continual use, only rehabilitation techniques that provide some structural integrity as well as corrosion protection were considered. The following rehabilitation alternatives were considered:

- Fold & Form
  - ✓ Polyvinyl chloride (PVC) or polyethylene (PE) non-reinforced liner.
  - ✓ Folded liner pipe reinforced with a circular woven polyester yarn (PRP).
  - ✓ Insitaform Polyfold – proprietary fold & form installation process using a custom designed close fitting polyethylene (PE) pipe.
- Swagelining
  - ✓ Thin wall polyethylene semi-structural liner option.
  - ✓ Thick wall polyethylene structural liner option.

- Cured In Place Pipe – resin impregnated seamless reconstruction sock type tube expanded in place with steam or hot water.

- Slip Lining – solid thermoplastic liner pipe pulled or pushed into the pipe with the annual space filled with grant.

- Pipe Bursting – using a hydraulically or pneumatically driven cone to burst the existing pipe while simultaneously feeding a replacement flexible pipe.

ES6.4 Existing Reclaimed Water Pipeline Hydraulic Analysis

The existing reclaimed water pipeline was installed 20 years ago with a design capacity of 7.5 mgd and Hagen-Williams friction coefficient (C value) of 110. For the centralized treatment approach the required peak wastewater conveyance capacity would be 10.8 mgd. In addition, pipe rehabilitation alternatives will reduce the pipe diameter. After rehabilitation with a thin wall smooth liner pipe (C2150) the 24 inch portion of the reclaimed water pipeline would provide sufficient for 10.8 mgd, however, the 18 inch segment would not.

ES6.5 Combination Reclaimed Water Pipeline with Airport WRF

The Sundog reclaimed water pipeline passes near the Willow Creek Intake along Highway 89 approximately half way between the Sundog WWTP and Airport WRF. There is an existing 24 inch diameter trunk sewer originating near the Willow Creek Intake which conveys wastewater to the Airport WRF. There is the potential to make use of this trunk sewer to convey raw wastewater from the Sundog WWTP to the airport WRF in combination with the 24 inch portion of the Sundog reclaimed water pipeline.

ES6.6 Wastewater Conveyance and Reclaimed Water Distribution

The Prescott Lakes Golf Course and area is currently supplied reclaimed water from the Sundog reclaimed water pipeline. If treatment is discontinued at the Sundog WWTP and the reclaimed water pipeline converted to wastewater conveyance, an alternative for reclaimed water distribution is required. Two overall wastewater conveyance and reclaimed water distribution alternatives were analyzed. The recommended alternative is shown in Figure ES6.1 and consists of the following elements:

- Rehabilitation of 24" Sundog reclaimed water pipeline for wastewater conveyance from the Sundog WWTP to Prescott Lakes Reclaimed Water PS.

- Utilizing the new 24" and 30" sewer piping from the Prescott Lakes Reclaimed Water PS to the vicinity of the Willow Creek Intake.

- Upsizing a proposed trunk sewer from near the Willow Creek Intake to the Airport WRF.
- Continued utilization of the reclaimed water pipeline system for distribution of reclaimed water from the Airport WRF to all existing customers, including Prescott Lakes via the Prescott Lakes Reclaimed Water PS.
- New reclaimed water PS at the Airport WRF.

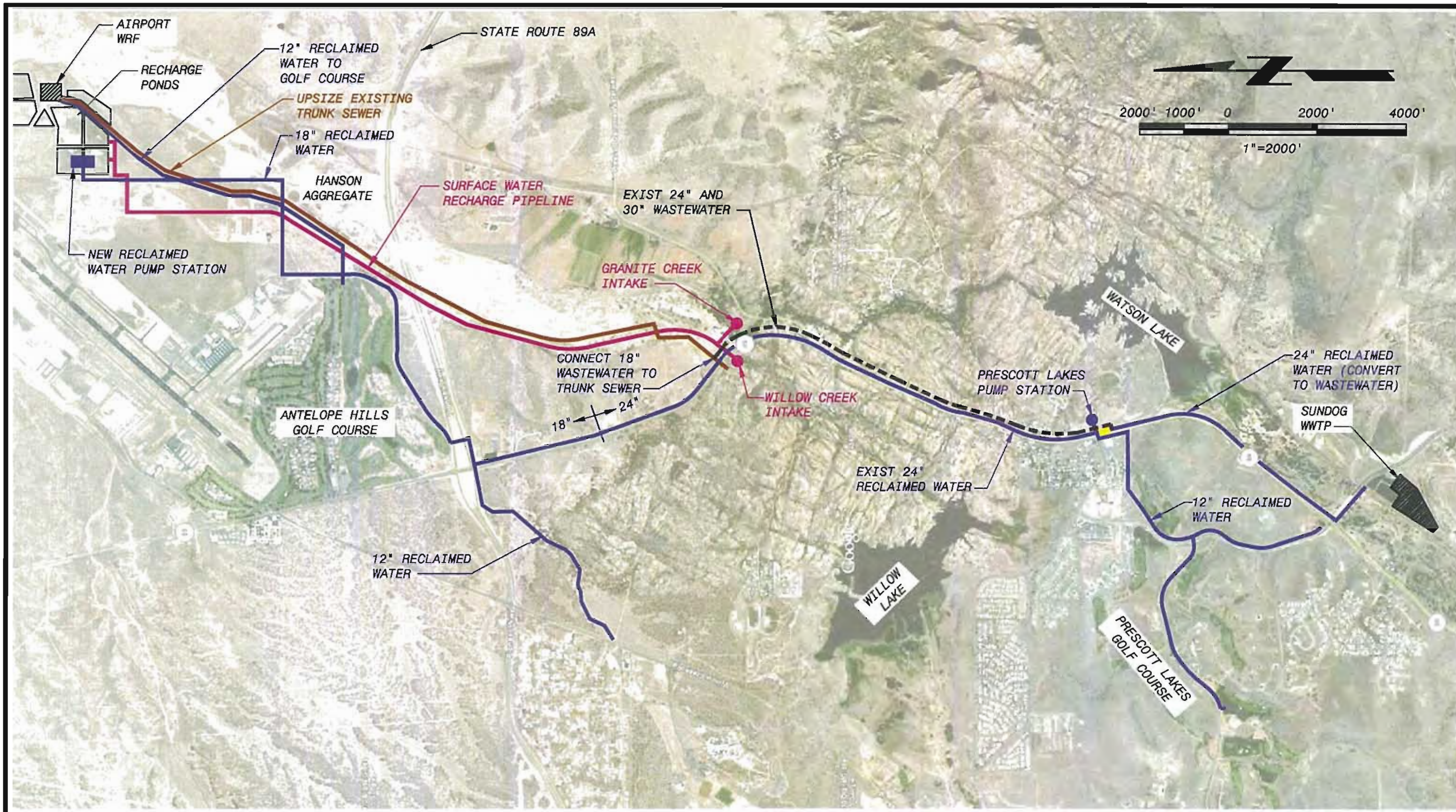


FIGURE ES.1
CENTRALIZED TREATMENT AT THE AIRPORT WRF:
WASTEWATER CONVEYANCE AND
RECLAIMED WATER DISTRIBUTION

ES6.7 Sundog WWTP Improvements

Under the centralized treatment at the Airport WRF approach, wastewater tributary to the Sundog WWTP would be conveyed to the Airport WRF. However, some minor improvements at the Sundog WWTP are still recommended, as follows:

- Maintain the existing preliminary treatment headworks (influent screens and grit removal) with minor improvements to the existing facilities.
- Provide flow equalization to reduce peak flow requirements in the conveyance pipeline.
- Provide odor control for the existing headworks and proposed flow equalization facility.

ES6.8 Airport WRF Improvements

The treatment technology recommended for the Airport WRF would be as recommended in TM 5A. The difference for the centralized approach is planning for an ultimate combined Sundog WWTP and Airport WRF capacity of 15 mgd rather than 9.6 mgd.

Planning for the larger ultimate capacity alters the recommended initial capacity and subsequent modular expansion capacities. As noted on Page ES-44, cost estimates in TM 5A are based on three Airport WRF modules of 3.2 mgd capacity each (9.6 mgd ultimate capacity). Under the centralized treatment approach (TM 6) phasing and cost estimates are based on four modules of 3.75 mgd each (15 mgd ultimate capacity).

The ultimate and Phase 1 design wastewater flows and peaking factors used for evaluation of centralized treatment at the Airport WRF are presented in Table ES6.1 and ES6.2.

Table ES6.1 Buildout Design Wastewater Flows and Peaking Factors Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona Centralized Treatment Feasibility Analysis				
Flow Criteria	**Airport WRF Buildout Flow, mgd(1)**	**Sundog WWTP Buildout Flow, mgd (1,2)**	**Combined Buildout Flow at Airport WRF, mgd (1,3)**	**Combined Hydraulic Peaking Factor (1,3)**
Annual Average Day Flow	9.6	5.4	15.0	1.00
Maximum Month Average Day	13.4	10.8	24.2	1.62
Peak Day	19.2	10.8	30.0	2.00
Peak Hour	28.8	10.8	39.6	2.64

Notes:

(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

(2) Based on the assumption that flow equalization facilities and/or collection system improvements result in peaking factors no greater than 2.0 for the Sundog WWTP service area flows.

(3) Based on the assumption that peak flows for the Airport WRF and Sundog WWTP service areas coincide when combined at the Airport WRF.

Table ES6.2 Phase 1 Design Wastewater Flows and Peaking Factors Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona Centralized Treatment Feasibility Analysis		
Flow Criteria	**Phase 1 Flow, mgd**	**Hydraulic Peaking Factor(1)**
Annual Average Day Flow	3.75	1.0
Maximum Month Average Day	5.25	1.4
Peak Day	7.50	2.0
Peak Hour	11.25	3.0

Note:

(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

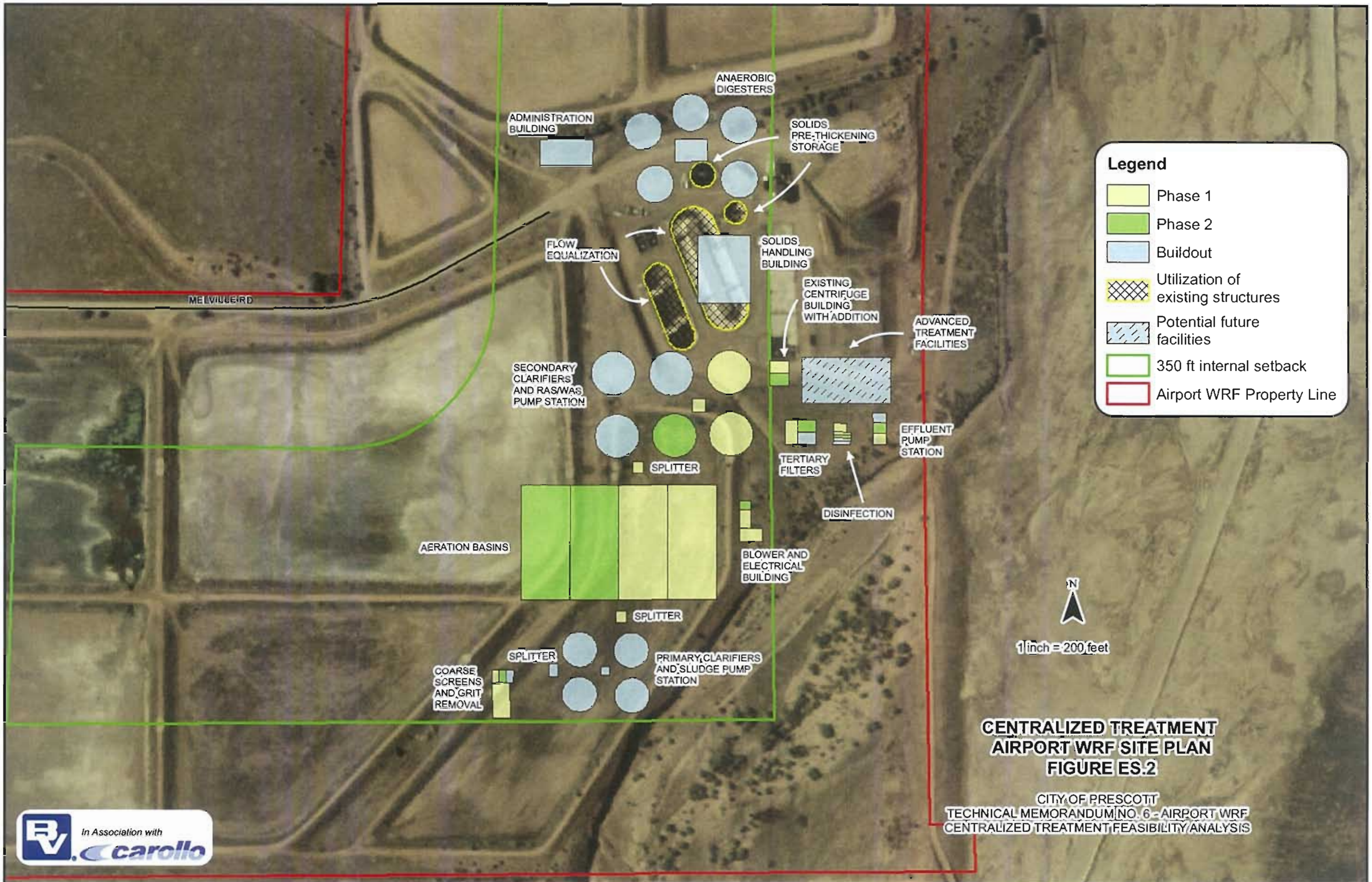
For centralized treatment at the Airport WRF, design wastewater characteristics are a compilation of characteristics observed at the existing Sundog WWTP and Airport WRF, Design characteristics for centralized treatment at the Airport WRF are presented in Table ES6.3.

Table ES6.3 Design Wastewater Characteristics Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona Centralized Treatment Feasibility Analysis			
Design Parameter	**Unit**	**Annual Average Day**	**Maximum Month Average Day (1)**
Flow	mgd	3.75	5.25
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity	mg/L	250	250
Temperature	°C	18.4	12.4

Note:

(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).

Figure ES6.2 presents a site plan of the recommended Airport WRF improvements for centralized treatment.



CENTRALIZED TREATMENT AIRPORT WRF SITE PLAN
FIGURE ES.2

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 6 - AIRPORT WRF
CENTRALIZED TREATMENT FEASIBILITY ANALYSIS

ES6.9 Decentralized Versus Centralized Treatment Comparison

The two approaches were evaluated based on economic and non-economic criteria.

ES6.9.1 Economic Comparison

A capital cost operating cost and present worth comparison of decentralized treatment versus centralized treatment are presented in Tables ES6.4 and ES6.5 respectively. The capital costs for decentralized treatment were brought forward from TM 5S and TM 5A.

Table ES6.4 Capital/Operating Cost and Present Worth for Decentralized Treatment at Sundog WWTP and Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP (5.4 mgd) (Build-out)	75.1	2.60	110.75
Airport WRF (9.6 mgd) (Build-out)	115.4	3.63	160.63
	190.5	6.23	271.38

Note:
[1] 20 yr Present Worth @ 5% interest.

Table ES6.5 Capital/Operating Cost and Present Worth for Centralized Treatment at Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP	10.4	0.5	17.27
Conveyance	5.3	0.2	8.05
Airport WRF (15 mgd)	160.7	4.73	225.66
	176.4	5.43	250.98

Note:
[1] 20 yr Present Worth @ 5% interest.

ES6.9.2 Non-Economic Comparison

The following non-economic criteria were used to compare decentralized versus centralized treatment:

- Effluent Quality & Permit Compliance
- Aging Infrastructure
- Operational Complexity
- Staffing/Requirements
- Training
- Ease of Maintenance

The criteria were weighted by importance from 1 to 4 and given a rating score from 1 to 10. Results of the non-economic comparison are presented in Table ES6.6.

Table ES6.6 Non-Economic Factor Comparison
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Weighting Factor	Continued Decentralized Treatment at Sundog WWTP and Airport WRF		Centralized Treatment at Airport WRF	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Effluent Quality	x 5	7	35	8	40
Aging Infrastructure	x 4	6	24	9	36
Operational Complexity	x 4	5	20	7	28
Staffing/Training Requirements	x 3	5	15	7	21
Ease of Maintenance	x 4	5	20	7	28
TOTAL			114		153

Note:
1. Comparison of non-economic factors where 10 = best and 1 = worst

ES6.10 Alternative Phasing and Capital Improvement Plans

The previous economic comparison was based on the costs of ultimate build-out facilities. Differences in phasing, initial cost and long term capital improvement plans were also reviewed relative to decentralized versus centralized treatment.

ES6.10.1 Centralized Treatment Phasing Plan

Projected flow curves for the Sundog WWTP (Figure ES6.3) and combined Sundog WWTP and Airport WRF (Figure ES6.4) flows were used to ideify timing of phased expansions for centralized treatment and the time frame for the City to decide between the centralized and decentralized treatment approaches.

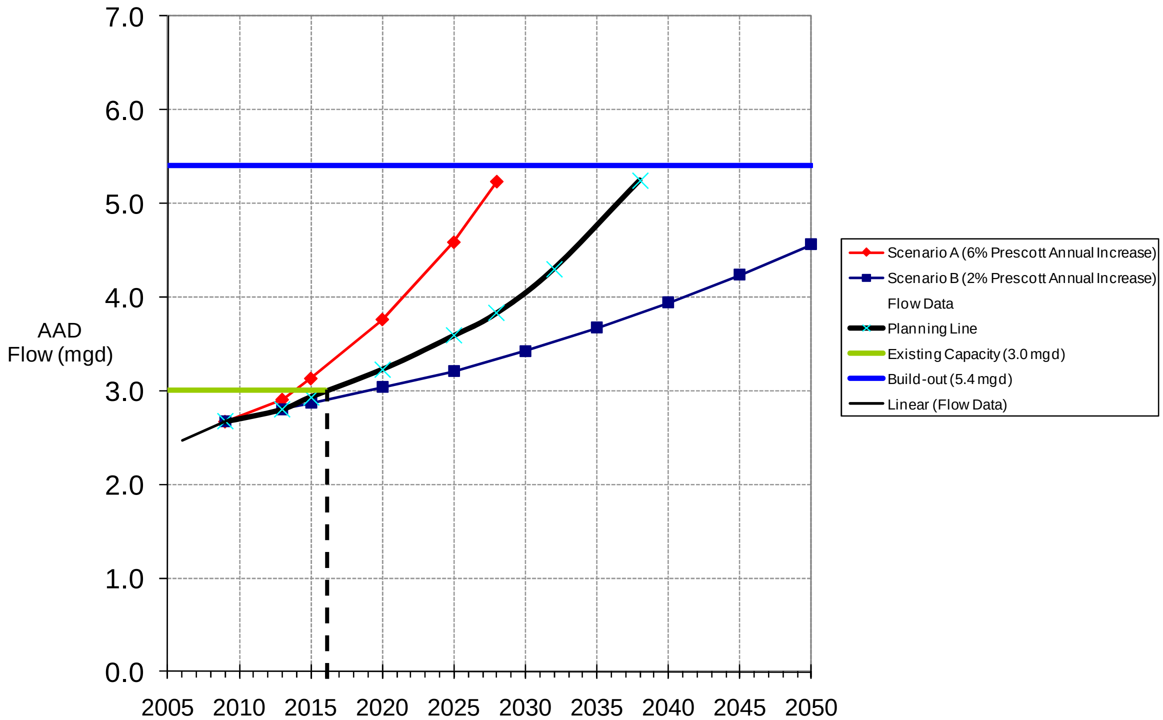


Figure ES6.3 Flow Increase Curves – Sundog WWTP

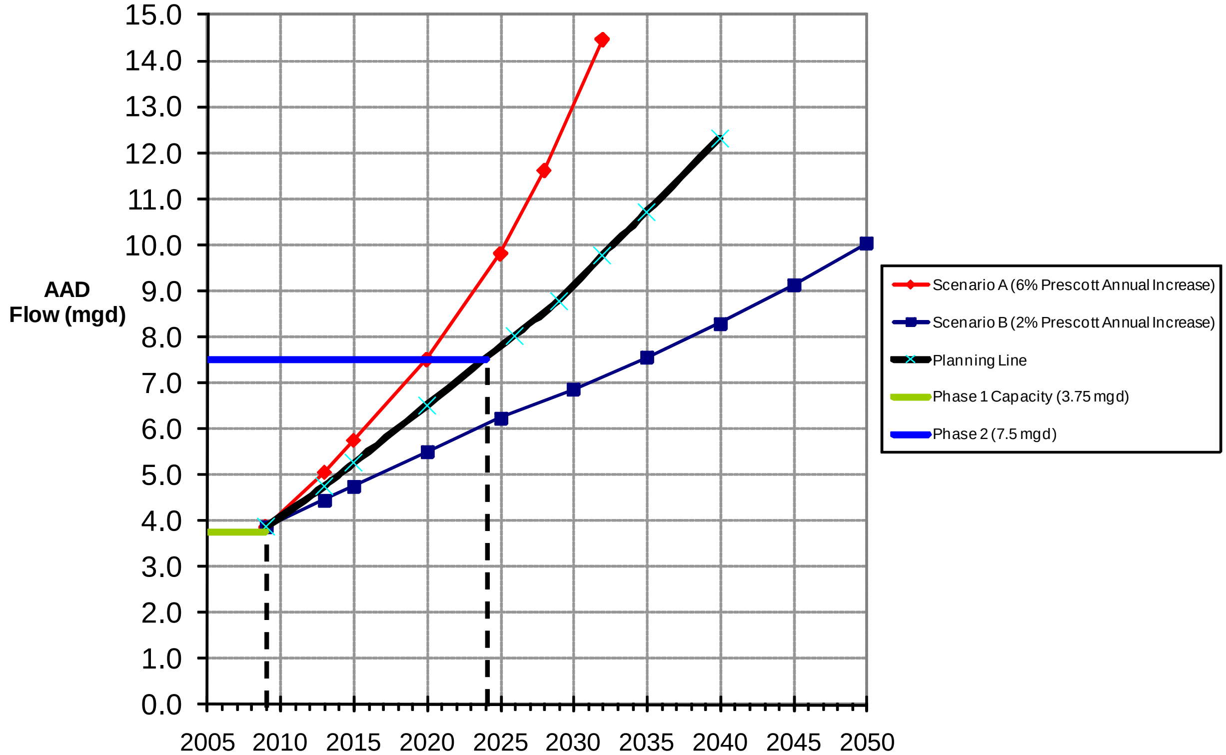


Figure ES6.4 Flow Increase Curves – Combined Sundog WWTP and Airport WRF

Based on flow projections, Figure ES6.5 identifies a schedule of improvements and an associated capital improvements program for centralized treatment.

The time to decide between centralized versus decentralized treatment depends on the life expectancy of the Sundog WWTP. Based on Figure ES6.3, that point is projected to occur in 2019. Allowing for time to design and implement improvements in 3 years, the decision point is identified in 2016.

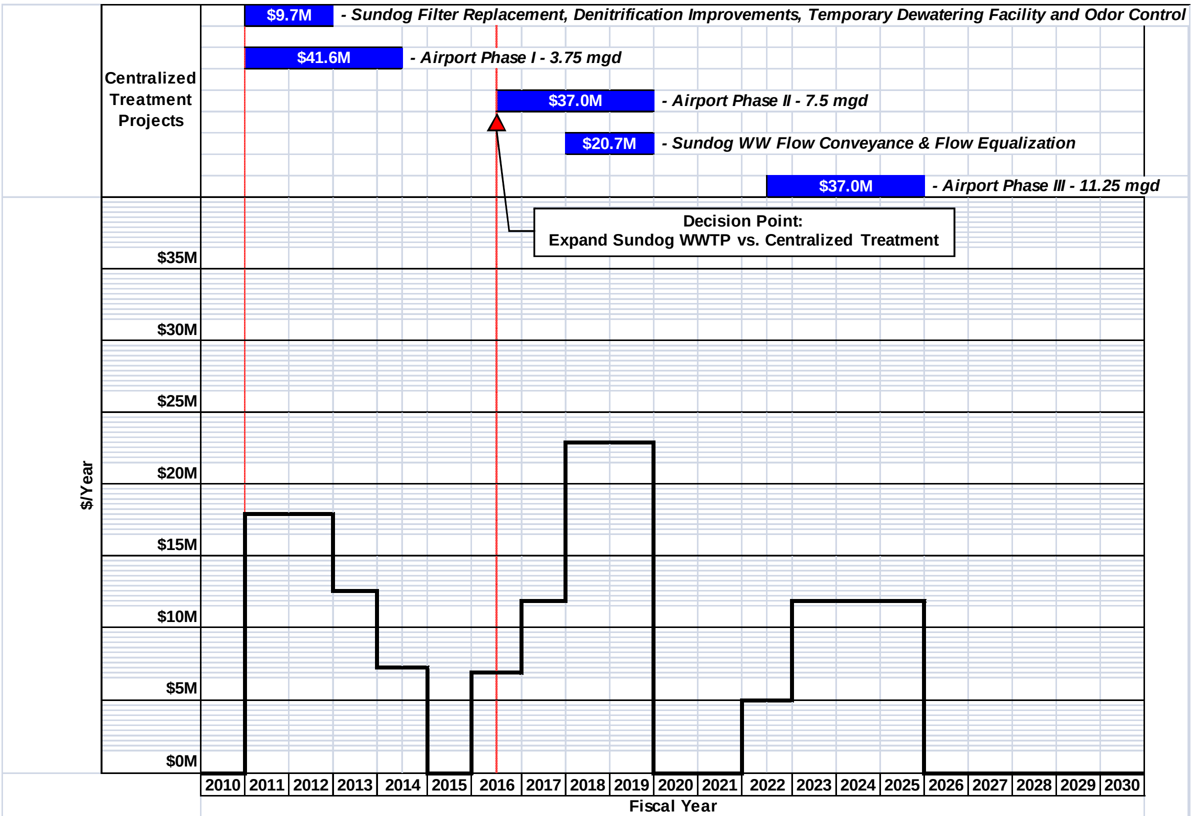


Figure ES6.5 Centralized Treatment CIP

ES6.10.2 Decentralized Treatment Phasing Plan

Figure ES6.6 presents the schedule of individual plant improvements and an associated capital improvements program for the decentralized treatment approach.

A comparison of cumulative capital costs for the centralized versus decentralized approaches is presented on Figure ES6.7.

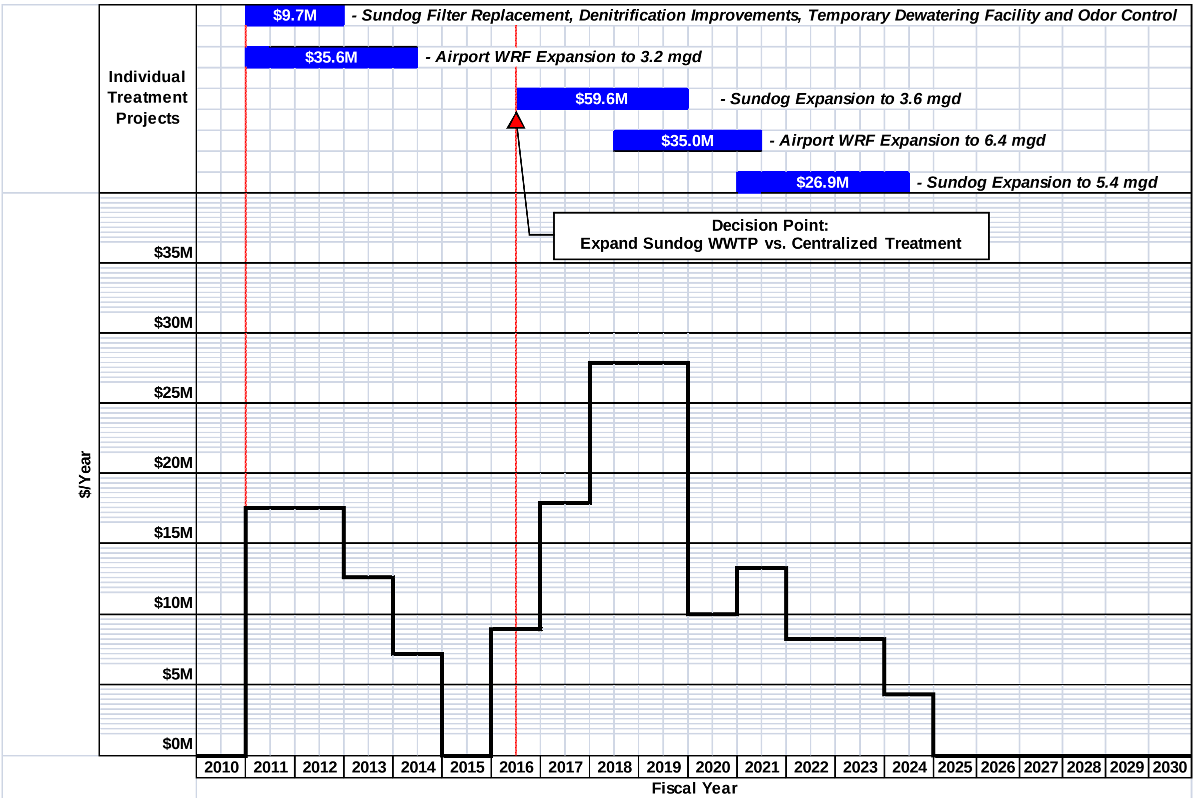


Figure ES6.6 Decentralized Treatment Plants CIP

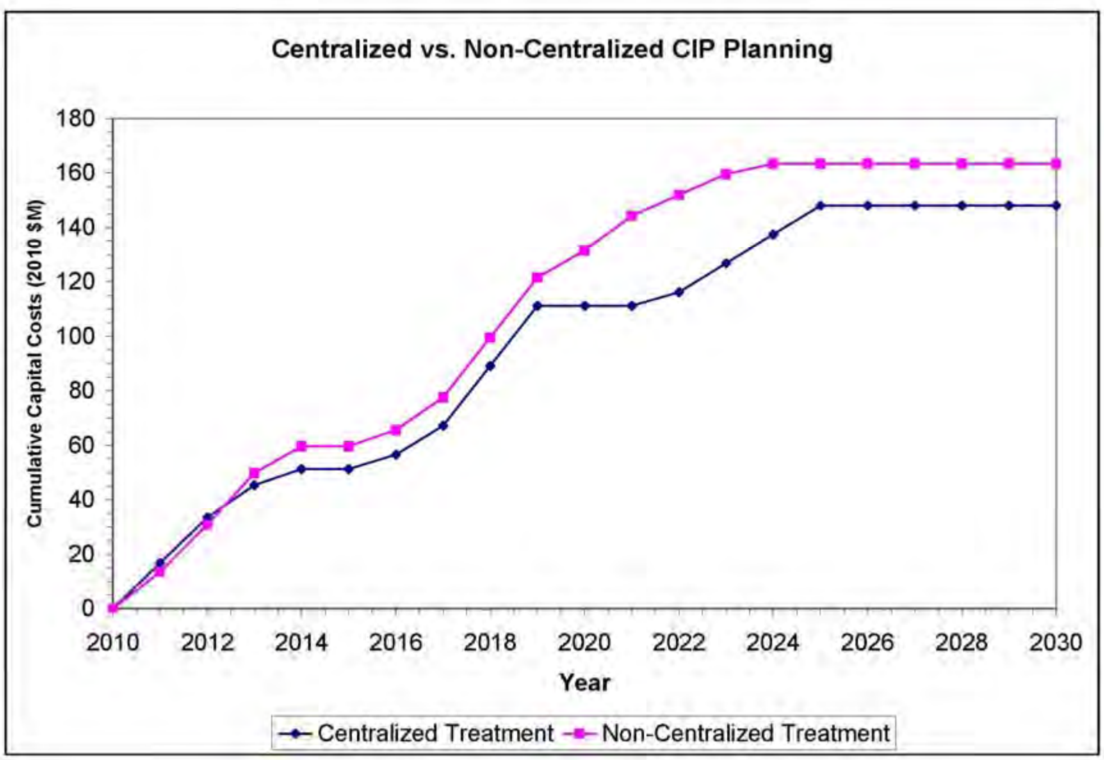


Figure ES6.7 Cumulative Capital Cost Comparison

ES6.11 Conclusions

The economic comparison (20-year present worth), non-economic comparison and the comparison of phasing plans and corresponding capital improvement plans show minor difference between centralized treatment at the Airport WRF and decentralized treatment at the Airport WRF and Sundog WWTP. It is recommended the City maintain both options for as long as possible. As such the following recommendations and conclusions are appropriate.

- Plan the first phase of the Airport WRF improvements for 3.75 mgd of capacity which provides the flexibility for either approach.
- Recognize that an initial capacity of 3.75 mgd for the Airport WRF does not dictate the centralized treatment approach.
- Plan to make a decision on centralized treatment 2016, provided the actual flow increases are consistent with the projections herein.
- Recognize that if actual flow increase are less than projected the centralized treatment decision can be postponed beyond 2016.
- Consider collection system alternatives to divert flow away from the Sundog WWTP to the Airport WRF. This will in effect prolong the life expectancy of the Sundog WWTP and postpone the centralized treatment decision point.
- Consider more aggressive approach to solving I/I problem vs. providing flow equalization

Technical Memorandum No. 6

1.0 Introduction

Given the estimated capital and operating costs associated with the recommended improvements at the Sundog WWTP and given the age and condition of the existing facilities at that plant, the City of Prescott wishes to conduct an analysis to see if it is feasible to eliminate most treatment processes at the Sundog WWTP and convey all wastewater to the Airport WRF for centralized treatment at a single facility.

2.0 Existing Facilities

2.1 Wastewater Treatment Facilities

The existing wastewater treatment facilities at the Sundog WWTP are described in TM #3S – Sundog WWTP Existing Conditions. The wastewater treatment facilities at the Airport WRF are described in TM #3A – Airport WRF Existing Conditions.

2.2 Conveyance Facilities

There is an existing transmission pipeline that conveys reclaimed water from the Sundog WWTP to the recharge ponds at the Airport WRF, as shown in Figure 2.1. This pipeline begins at the reclaimed water storage ponds at the Sundog WWTP and could potentially be converted to a wastewater pipeline. The existing pipeline is an 18-inch and 24-inch diameter concrete cylinder pipe (CCP). The reclaimed water pipeline runs north, parallel to State Route (SR) 89 for approximately 4 miles to SR 89-A near the Antelope Hills Golf Course. Approximately 0.5 miles before SR 89-A, the pipeline size reduces to 18-inch diameter. At SR 89-A, the 18-inch CCP turns east adjacent to the Antelope Hills Golf Course and runs along the airport commercial/industrial park area to the Airport WRF recharge ponds. The flow in this transmission pipeline is by gravity and was designed for a maximum flow capacity of 7.5 mgd. There are three primary branch lines connecting to the main pipeline and these branches distribute reclaimed water to: (1) the Prescott Lakes Golf Course, (2) the Antelope Hills Golf Course, and (3) Hanson Aggregate. The reclaimed water demands at these locations peak during summertime irrigation demand periods. Monthly demands during Year 2009 are shown in Figure 2.2 to illustrate typical seasonal demands for these users. There is also a secondary distribution line that runs west through the Rifle Ranch. A second 12-inch reclaimed water pipeline feeds the Antelope Hills Golf Course through a pump station at the Airport WRF. The City also has the ability to pump groundwater from the Airport WRF into the reclaimed water pipeline and back feed the system to meet reclaimed water demands.

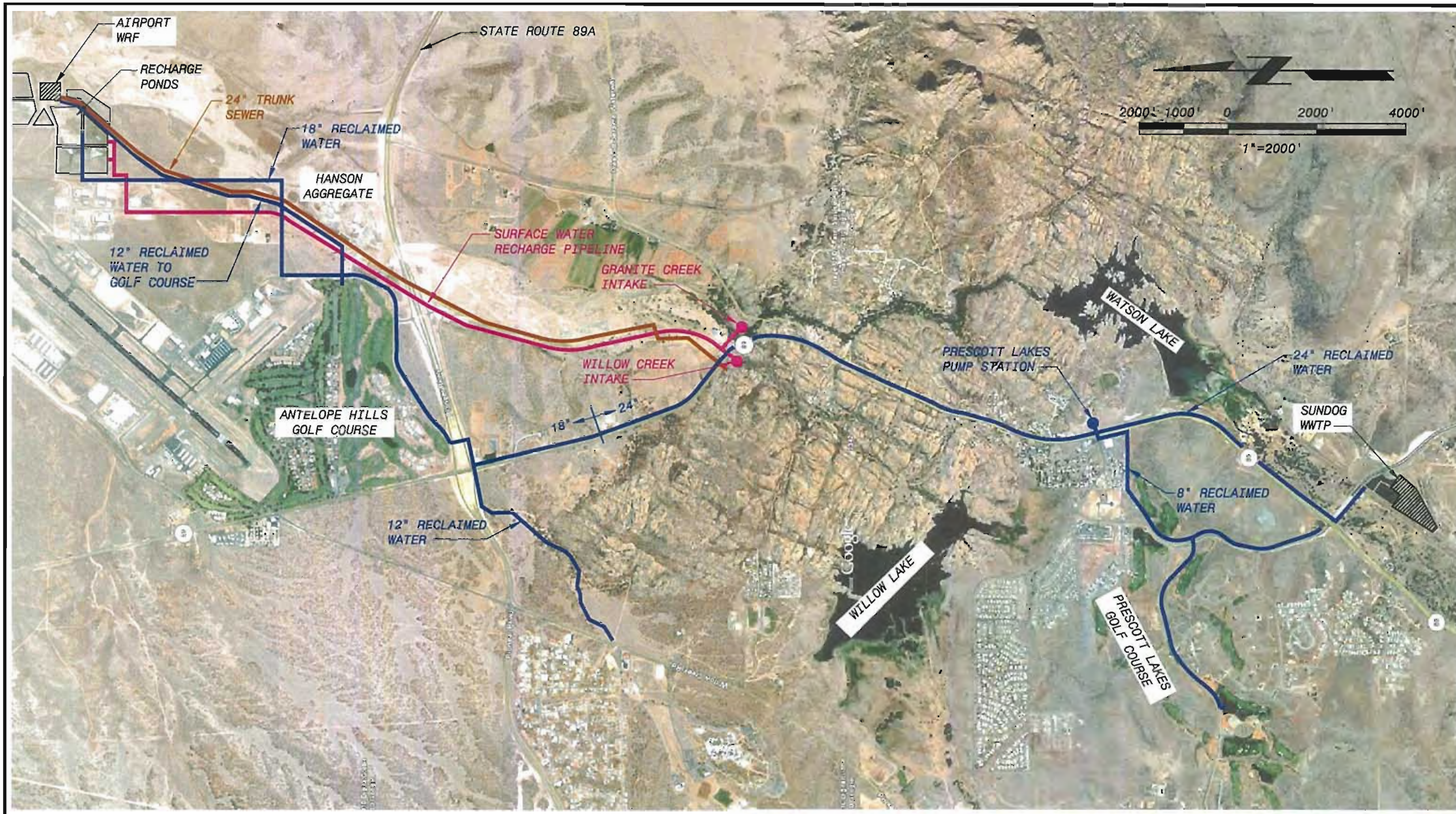
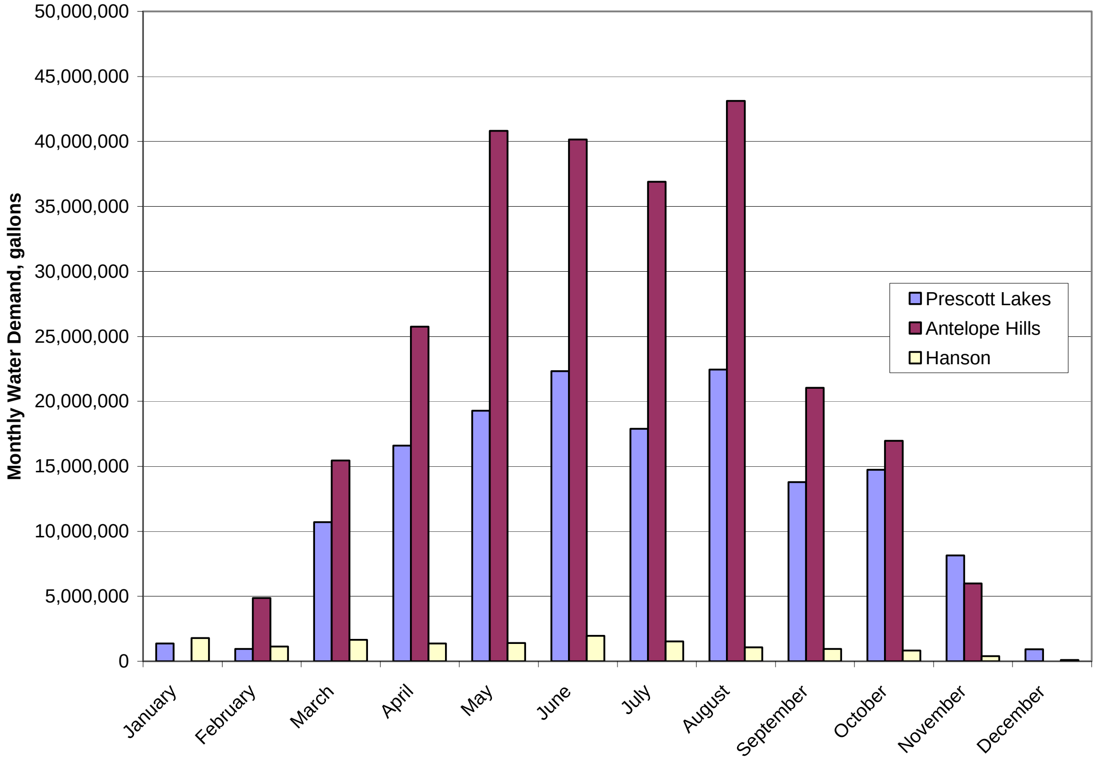


FIGURE 2.1
EXISTING RECLAIMED WATER TRANSMISSION, DISTRIBUTION, AND RECHARGE FACILITIES

Figure 2.2
2009 Reclaimed Water Demands



In addition to recharging reclaimed water, the City of Prescott recharges surface water from Granite Creek and Willow Creek via two intake structures and a transmission pipeline to the Airport WRF. Upgrades to this pipeline are currently under design in a separate project.

Near the Willow Creek Intake, there is an existing 24-inch diameter PVC trunk sewer Hobas (new) and Clay (existing) conveying wastewater to the Airport WRF (see Figure 2.1). Since this trunk sewer crosses the 24-inch reclaimed waterline in this location, the alternative to discharge wastewater from the converted reclaimed water pipeline into this trunk sewer will also be considered.

3.0 Reclaimed Water Pipeline Rehabilitation Alternatives

The existing reclaimed water pipeline could be used to convey wastewater from the Sundog WWTP to the Airport WRF, but would require pipeline rehabilitation for this service.

3.1 Overview of Rehabilitation Alternatives

The existing reclaimed water pipeline is not known to be leaking or have structural/corrosion damage, although there has been no comprehensive inspection of the pipeline since its construction approximately 20 years ago, because it can't be isolated. Pipe rehabilitation is recommended to achieve proper protection from corrosion due to conveyance of wastewater. A collateral benefit of rehabilitating the pipeline may be to eliminate unknown leaks and provide additional structural capacity in the pipeline.

Nonstructural pipeline rehabilitation techniques include cement mortar lining, joint sealing, and epoxy lining. Only epoxy lining would provide the necessary corrosion protection for raw wastewater service. This alternative could be considered and would represent a lower cost option. However, regular inspections would be recommended approximately every 3 years in order to identify any lining failures that develop over time and there would be downtime associated with any repairs that are needed. For this evaluation only rehabilitation techniques that provide some structural integrity will be considered.

A number of internal lining techniques are available for rehabilitation of the reclaimed water pipeline that provide corrosion protection and some structural integrity. Factors to consider in evaluation of these techniques include hydraulic flow requirements, constructability issues, reconnection of branch (distribution) lines, and costs. This technical memorandum briefly evaluates and discusses the technical feasibility of internal liner rehabilitation techniques that could be implemented and recommends a preferred alternative(s) and associated costs to be used in the feasibility analysis for conveyance of Sundog WWTP influent flow to the Airport WRF.

3.1.1 Fold & Form

A Fold & Form system is a trenchless rehabilitation system that uses folded pipes placed into the existing pipeline and then expanded using pressure and/or heat. The Fold & Form system typically uses polyvinyl chloride (PVC) or polyethylene (PE) pipe and once expanded provides a tight fit to the existing pipeline.

Fold & Form lining before and after

3.1.1.1 Non-reinforced

The Fold & Form option is available as a non-reinforced liner. This would be a typical PVC or PE pipe folded and then expanded within the pipeline. This option would stop leaks, span holes, provide internal corrosion protection and possibly increase the Hazen-Williams roughness coefficient (C-value). The non-reinforced option of the Fold & Form liner rehabilitation would be less expensive than the reinforced option. This option may also be slightly easier to install and expand as opposed to the reinforced Fold & Form option.

3.1.1.2 Reinforced

The Fold & Form option is also available as a reinforced liner. This would be a folded pipe reinforced with a circular woven polyester yarn (PRP) or similar material that is expanded within the pipeline. This option would stop leaks, span holes, provide internal corrosion protection, provide enhanced structural support and possibly increase the Hazen-Williams roughness coefficient (C-value).

3.1.1.3 Insituform Polyfold®

This proprietary installation process is similar to fold and form but uses a close fitting polyethylene pipe (PE) that is custom designed to match the existing conditions for the pipe to be rehabilitated. The pipe is fused together in length for the project and then held together by bands that are broken after installation into the host pipe as shown in Figure 3.1. This process allows for longer than traditional fold and form lengths to be installed. The polyethylene can be thin walled to minimize the area loss or thick walled to provide the required strength to span openings.

Figure 3.1 PE Pipe in Insituform Polyfold Machine

3.1.1.4 Advantages of Fold & Form

The following are some of the advantages of Fold & Form liner rehabilitation:

- Minimal cross sectional loss
- Tightly fits to existing pipeline
- Improved C-value
- Negotiates sweeping bends
- Branch connections can be re-opened remotely

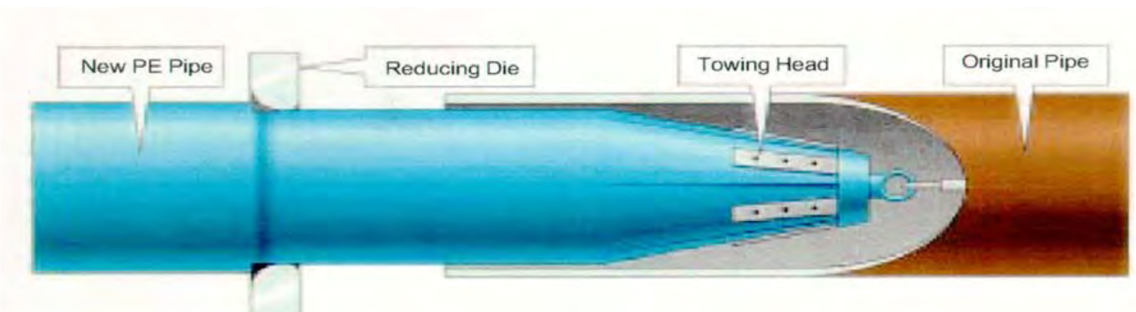
3.1.1.5 Disadvantages of Fold & Form

The following are some of the disadvantages of Fold & Form liner rehabilitation:

- Requires excavation for reconnection of branch lines
- Limited installation distance for 24" pipe (excludes Insituform)
- May move after installation (excludes Insituform)

3.1.2 Swagelining

Swagelining is a trenchless rehabilitation technique that involves running the pipe through a die to slightly reduce its diameter and allow it to be pulled through the host pipe. The liner is kept under tension which maintains the reduced diameter allowing it to pass through the existing pipeline. Once through, the tension is relieved and the new lining will elastically recover to its original dimensions. If necessary heat may be added to further enhance this process.



The PE pipe is reduced slightly during the installation process. This allows it to be pulled easily through an existing pipeline.

Figure 3.2 Demonstration of Swage Lining Entering Existing Pipeline

3.1.2.1 Swagelining with Thin PE

Because of the reduced thickness, swagelining with thin polyethylene is only a semi-structural liner option. However, this option would be less expensive and have a smaller inside diameter (ID) than the thick polyethylene option. This option would stop leaks, span holes, provide internal corrosion protection and possibly increase the C-value.

3.1.2.2 Swagelining with Thick PE

Because of the increased thickness, swagelining with thick polyethylene is considered a structural option. This option would stop leaks, span holes, provide internal corrosion protection, provide enhanced structural support and possibly increase the C-value.

3.1.2.3 Advantages of Swagelining

The following are some of the advantages of Swagelining rehabilitation:

- Minimal cross sectional loss
- Tightly fits to existing pipeline
- Improved C-value
- Branch connections and taps can be made easily

3.1.2.4 Disadvantages of Swagelining

The following are some of the disadvantages of Swage liner rehabilitation:

- Impacts of placing the pipe in tension reduces strength
- May require larger construction trenches
- Requires skilled labor, limited contractors can perform this work
- Does not easily navigate bends
- The liner may crack when making service connections

3.1.3 Cured In Place Pipe (CIPP)

Cured in place pipe is a seamless pipe within a pipe that is expanded and solidified once inside. This option utilizes resin transported through a matrix of materials. This matrix may consist of either felt or woven polyester fibers. Once in place either steam or hot water is used to expand and cure the resin causing a tight fitting bond upon the current internal pipeline wall.

Another option that is viable is to reverse the tubing at the start of an opening and allow water pressure to carry the CIPP liner in place throughout the pipe. This method is represented in Figure 3.3.

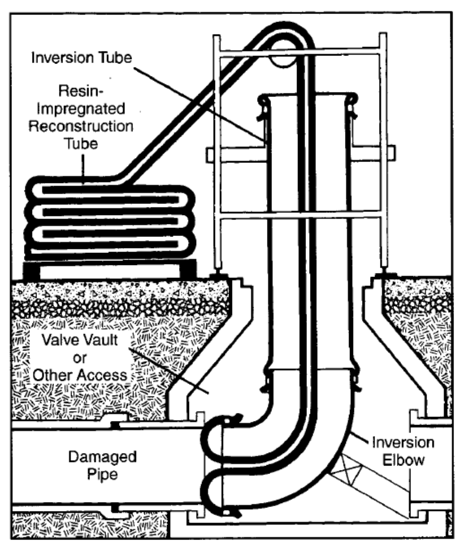


Figure 3.3 Demonstration of Reverse CIPP Lining

3.1.3.1 Advantages of CIPP

The following are some of the advantages of CIPP liner rehabilitation:

- Minimal cross sectional loss
- Tightly fits to existing pipeline
- Improved C-value
- Easily navigates bends
- Minimal construction footprint
- Branch lines can be reconnected remotely

3.1.3.2 Disadvantages of CIPP

The following are some of the possible disadvantages of CIPP liner rehabilitation:

- Installation is more complex
- Installation distance is limited compared with other options and this can increase construction costs

3.1.4 Slip-Lining

Slip-lining is the addition of a thermoplastic liner applied directly into the existing pipeline. Typically the new pipe is thermally fused above ground to create one uninterrupted pipeline. This method can use any flexible thermoplastic liner. It is pushed through the pipeline from the inlet or pulled through the existing pipeline from the outlet.

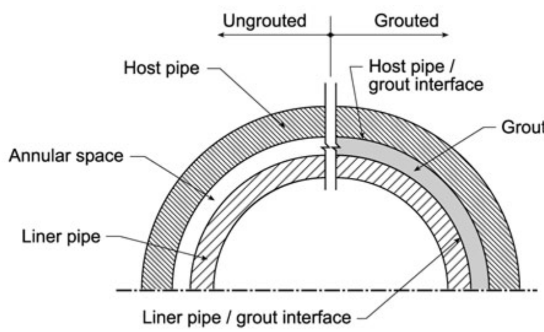


Figure 3.4 Slip-Lining

3.1.4.1 Advantages of Slip-Lining

The following are some advantages of Slip-Lining rehabilitation:

- Improved C-value
- Easy construction

3.1.4.2 Disadvantages of Slip-Lining

The following are some disadvantages of Slip-lining rehabilitation:

- Significant cross sectional area loss
- Annulus space must be grouted

- Does not easily navigate bends
- May require large construction trenches
- Possible difficulty reconnecting service lines and branches

3.1.5 Pipebursting

Pipebursting is the technique used to replace an existing pipe with a new one in the same location as the old one. This is done either pneumatically or hydraulically with a cone shaped tool by "bursting" the in place pipe while at the same time feeding a flexible pipe along behind it. Depending upon the method of installation either continuous flexible piping can be installed or individual pieces can be implemented depending upon the desired construction footprint.

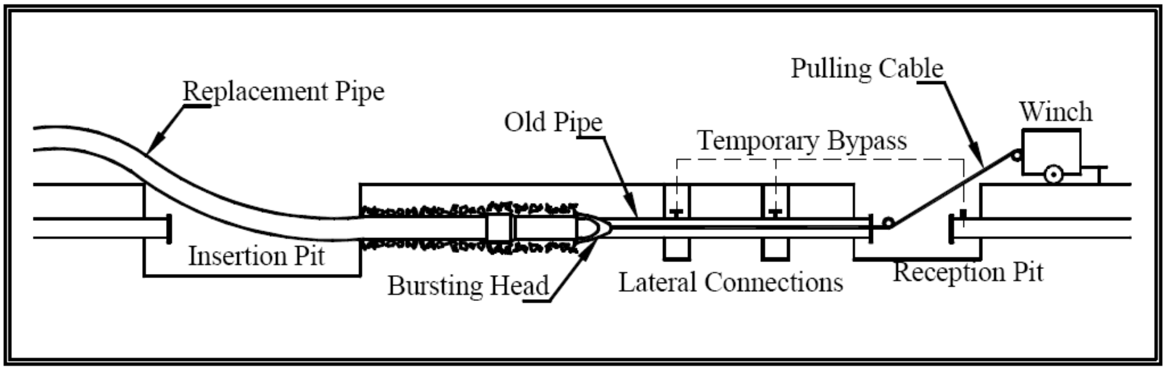


Figure 3.5 Demonstration of Pipebursting

3.1.5.1 Advantages of Pipebursting

The following are some of the possible advantages of Pipebursting and Pipe Splitting:

- Improved C-value of pipe installed
- Pipe diameter can be increased to provide additional flow capacity to meet projected demands

3.1.5.2 Disadvantages of Pipebursting

The following are some of the possible disadvantages of Pipebursting and Pipe Splitting:

- May require large construction trenches
- May have difficulty bursting concrete cylinder pipe
- Existing soil conditions (cobbles and boulders) can create difficulty
- Limited lengths can be installed at a single setup
- Possible difficulty at connections

3.2 Critical Pipe Rehabilitation Technique Selection Factors

This section provides a discussion of the critical factors in recommending a pipe rehabilitation techniques.

3.2.1 Cross Sectional Impact

The cross sectional impact of pipeline rehabilitation has a potentially significant impact on hydraulic capacity. Although the majority of the options decrease the inside diameter, other factors such as the effect of the liner on the C-value also must be considered. Most of the options increase the pipe's effective C-value which, depending upon the reduction in diameter, can minimize capacity loss and potentially increase hydraulic capacity.

The original reclaimed water pipeline was designed for a maximum capacity of 7.5 mgd. The build-out capacity of the Sundog WWTP is 5.4 mgd according to the City's Collection System Master Plan. Flow equalization facilities are planned for the Sundog WWTP that will equalize flows above maximum monthly flows with a peaking factor of 2.0; therefore, the converted pipeline must convey 10.8 mgd of raw wastewater to the Airport WRF. A preliminary hydraulic evaluation of the various alternatives suggests that slip lining and any thick walled pipe alternatives may result in excess cross sectional area loss and a flow capacity less than the required 10.8 mgd.

3.2.2 Constructability

Constructability of a rehabilitation technique is an important factor as it can impact the time required to complete the work and material and/or labor costs directly. Some methods such as sliplining and fold and form require minimal skill to install whereas a technique like pipebursting, CIPP, and Swagelining may require a much more skilled labor crew. For this relatively long pipeline (7 miles) alternatives such as fold and form, Swagelining, and slip lining offer significantly longer installation distance in a single set up for a contractor (runs in excess of 1,000 feet are possible). This may offer a cost advantage for these alternatives. There are two constructability considerations that may preclude pipe bursting: (1) it may be difficult to burst CCP and (2) certain soil conditions (hard soil and very well compacted soil) may preclude pipe bursting. Alternatives such as slip lining and pipe bursting require large trenches for installation compared with other options. Swagelining and slip lining do not easily navigate bends in the existing piping system and this could increase the number of excavations required for successful installation. All alternatives would require extensive by-pass pumping to maintain the reclaimed water pipeline in service during the rehabilitation efforts.

3.2.3 Reconnection of Branch Lines

The reconnection of branch lines is important to any rehabilitation job. This project contains a limited number of branch lines that will require reconnection once the rehabilitation process is complete. While some methods can remotely install the connections others require manual installation.

3.2.4 Costs

There are several factors that are to be considered in developing the estimated cost for the alternatives. The factors include unexpected construction or bidding conditions, variations in material costs, and potential environmental and political impacts. Each of the alternatives will require the cost for excavation of pits for construction, traffic control costs, and by-pass pumping impacts. In addition to rehabilitation costs, the total project cost includes expenditures for engineering services, contingencies, legal, administrative and financing services. These additional costs are estimated to be 50% of the rehabilitation cost. Cost estimates are not intended to represent the lowest price which may be achieved but are to provide a method for comparison of alternatives to complete the work.

Following are estimated project costs for the most promising alternatives for rehabilitating the existing 24-inch CCP and are based upon estimates without the use of field data or formal preliminary design. The estimated costs are developed based on experience from similar projects, discussions with contractors, input from vendors, and published cost estimates.

- Fold & Form - $150/ft x 1.5 = $225/ft
- Insituform Polyfold - $200/ft x 1.5 = $300/ft
- Swagelining - $175/ft x 1.5 = $262/ft

Based on this cost data, we recommend using $260 per foot for rehabilitating the 24-inch CCP and $210 per foot for the 18-inch CCP for this feasibility analysis.

3.3 Planning Level Pipe Rehabilitation Conclusions

The most promising rehabilitation alternatives for this feasibility analysis are fold & form, Insituform Polyfold, and Swagelining. These methods provide the tight fit, thin walled liner that minimizes cross sectional area loss in the existing pipe.

4.0 Existing Reclaimed Water Pipeline Hydraulic Analysis

The existing reclaimed water transmission pipeline was designed approximately 20 years ago with a design capacity of 7.5 mgd. Figure 4.1 shows a hydraulic profile of the pipeline at the design flow and with a Hazen-Williams friction coefficient (C value) of 110 that confirms this capacity. If the existing pipeline were used to convey wastewater at the higher required capacity of 10.8 mgd without rehabilitation (C = 110), the pipeline would not have sufficient capacity. Even if the existing transmission pipeline is rehabilitated with thin smooth wall piping (C = 150), the hydraulic grade line drops below the pipeline before reaching the Airport WRF and therefore does not have sufficient capacity – see Figure 4.2. The loss in cross sectional area due to a slightly smaller diameter and the friction loss in the 18-inch piping are too large to be offset by the smoother pipe wall (larger C value). However, the upstream 24-inch piping does provide sufficient capacity.

FIGURE 4.1
HYDRAULIC PROFILE - EXISTING RECLAIMED WATER TRANSMISSION PIPELINE
Q=7.5 mgd / C=110 (Concrete)

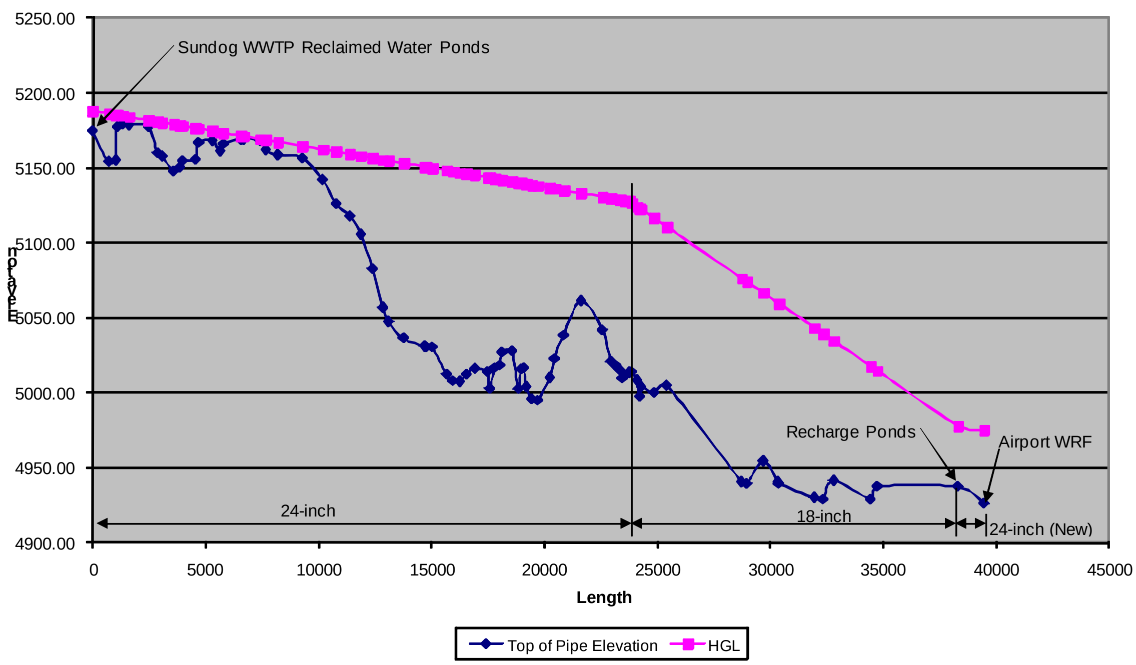
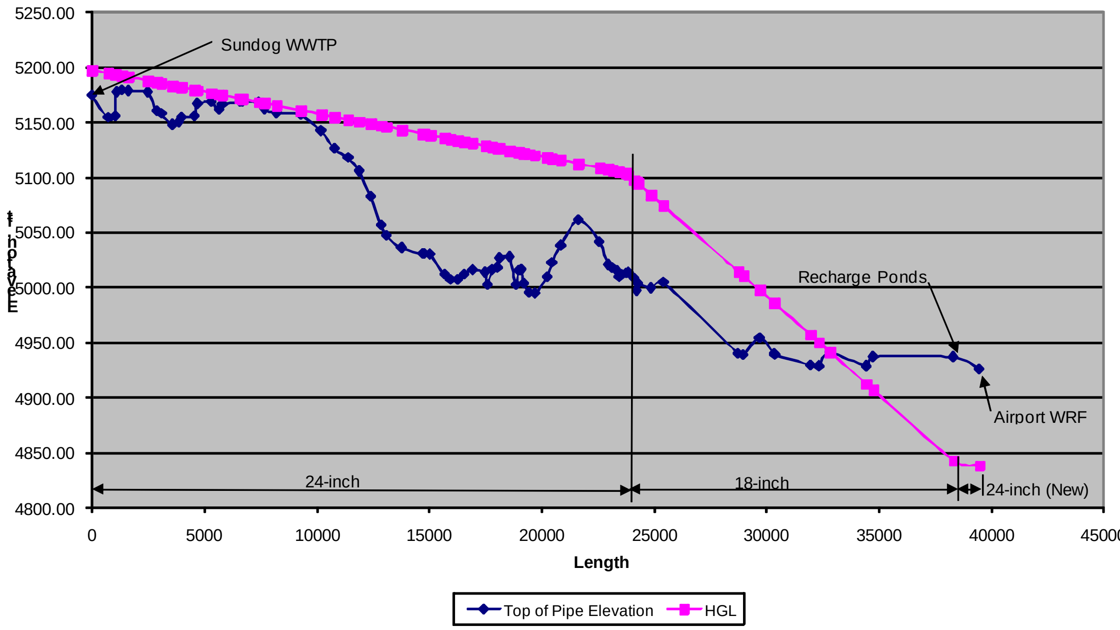


FIGURE 4.2
HYDRAULIC PROFILE - REHABILITATE EXISTING RECLAIMED WATER TRANSMISSION PIPELINE
Q=10.8 mgd / C=150 (Thin Walled Lining)



5.0 Combination Reclaimed Water Pipeline with Airport WRF Trunk Sewer

5.1 Airport WRF Trunk Sewer

As noted in Section 2.0, near the Willow Creek Intake there is an existing 24-inch diameter trunk sewer conveying wastewater to the Airport WRF (see Figure 2.1). There is the potential to make use of this trunk sewer to assist in conveying raw wastewater flows from the Sundog WWTP to the Airport WRF in combination with the 24-inch reclaimed water pipeline between the Sundog WWTP and the Willow Creek Intake. According to the Collection System Master Plan, this trunk sewer is scheduled to be upgraded with a parallel trunk sewer to convey projected flows to the Airport WRF through build-out conditions. Table 5.1 shows the pipe diameter and pipe lengths associated with the future parallel trunk sewer from the master plan. In order to accommodate the increased flows associated with eliminating treatment at the Sundog WWTP, this parallel trunk sewer would need to be increased by one pipe size for each length, as shown in Table 5.1. The cost increase for upsizing the replacement trunk sewer to a larger size is then calculated in Table 5.1 based on an assumed cost increase of $10 per inch diameter, per foot of sewer pipe. The total cost to increase the size of the trunk sewer is approximately $990,000.

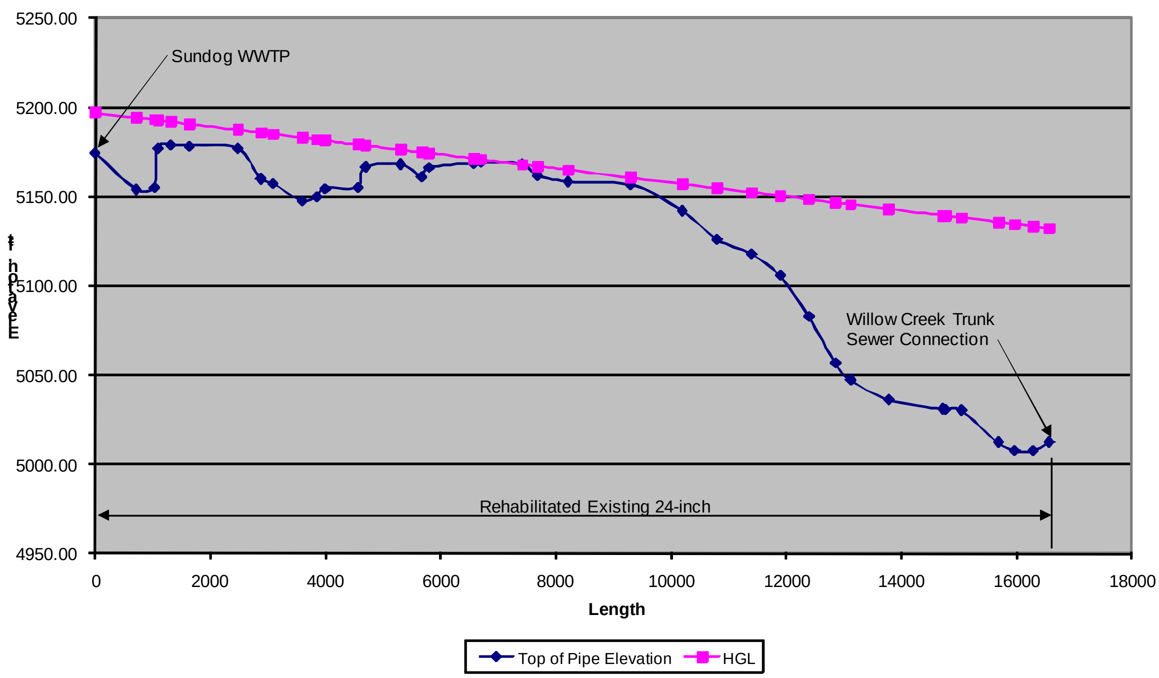
Table 5.1 Estimated Cost to Upsize Trunk Sewer
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Trunk Sewer Master Plan Recommendation At Build-Out		**Upsize Recommendation For Additional 10.8 mgd Sundog Flow**		**Estimated Upsize Cost**
Pipe Diameter (in)	Length (ft)	Pipe Diameter (in)	Length (ft)	
24	3,200	27	3,200	$ 96,000
24	4,200	30	4,200	$ 252,000
30	2,700	36	2,700	$ 162,000
36	8,000	42	8,000	$ 480,000
Total	18,100		18,100	$ 990,000

5.2 Replace or Rehabilitate the Reclaimed Water Pipeline

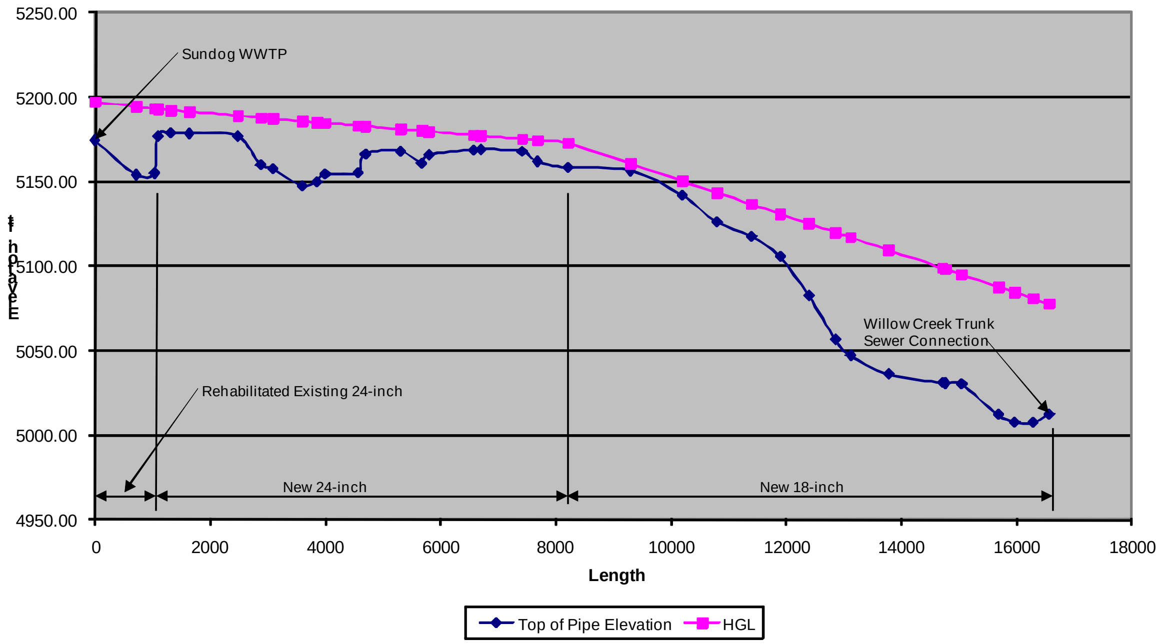
One alternative to convey wastewater from the Sundog WWTP to the trunk sewer is by rehabilitating the existing 24-inch reclaimed water pipeline from the Sundog WWTP to the Willow Creek Intake. The hydraulic analysis for this option is presented in Figure 5.1. The rehabilitated pipeline shows sufficient hydraulic capacity assuming a peak flow of 10.8 mgd and C=150.

Figure 5.1
HYDRAULIC PROFILE - REHABILITATE EXISTING 24" TO WILLOW CREEK INTAKE
Q=10.8 mgd / C=150 (Thin Walled Lining)



Another alternative for consideration is to replace a portion of the existing reclaimed water pipeline from the Sundog WWTP to the Willow Creek Intake vicinity. The hydraulic analysis for this alternative is summarized in Figure 5.2. There would be three sections of piping or rehabilitation segments associated with the 24-inch reclaimed water from the Sundog WWTP to the Willow Creek Intake vicinity: (1) the first section is assumed to be rehabilitation of the existing 24-inch CCP from the Sundog WWTP, across the Watson Woods Riparian Preserve, to SR 89, (2) section two is a new 24-inch HDPE sewer along SR 89 for approximately 7,100 feet, and (3) the third section is a new 18-inch HDPE sewer along SR 89 to the Willow Creek Intake vicinity. Wastewater would then discharge into the upsized trunk sewer for conveyance to the Airport WRF. Assuming a design flow of 10.8 mgd and a Hazen-Williams C-factor of 150, the hydraulic capacity of this wastewater pipeline appears sufficient since the hydraulic grade line is at or above the pipe.

FIGURE 5.2
HYDRAULIC PROFILE - REHAB 24" ACROSS GRANITE CREEK / NEW PIPELINE TO WILLOW CREEK INTAKE
Q=10.8 mgd / C=150 (Thin Walled Lining)



We note that this alternative assumes that there is sufficient space along SR 89 for constructing a new pipeline. This may be challenging as there appears to be very little space along the highway through the Dells. Also, there is potential for rock excavation through the Dells that could be problematic for constructing a new pipeline. There has been no detailed pipe alignment study with an easement analysis, utility evaluation, and geotechnical investigation. This detailed study is recommended before pursuing this alternative. Also, a more detailed hydraulic analysis is recommended should this alternative be considered further.

6.0 Reclaimed Water and Wastewater Conveyance Alternatives

Based on the analysis above, two alternatives are identified for conveying raw wastewater from the Sundog WWTP to the Airport WRF. Alternative No. 1 converts the existing reclaimed water pipeline between the Sundog WWTP and the trunk sewer near the Willow Creek Intake to wastewater service, as depicted in Figure 6.1. From that point, wastewater would be diverted into the existing (upsized) trunk sewer going to the Airport WRF. In order to continue to furnish reclaimed water to existing users, a new reclaimed water pump station at the Airport WRF is required that will pump through the existing 18-inch reclaimed

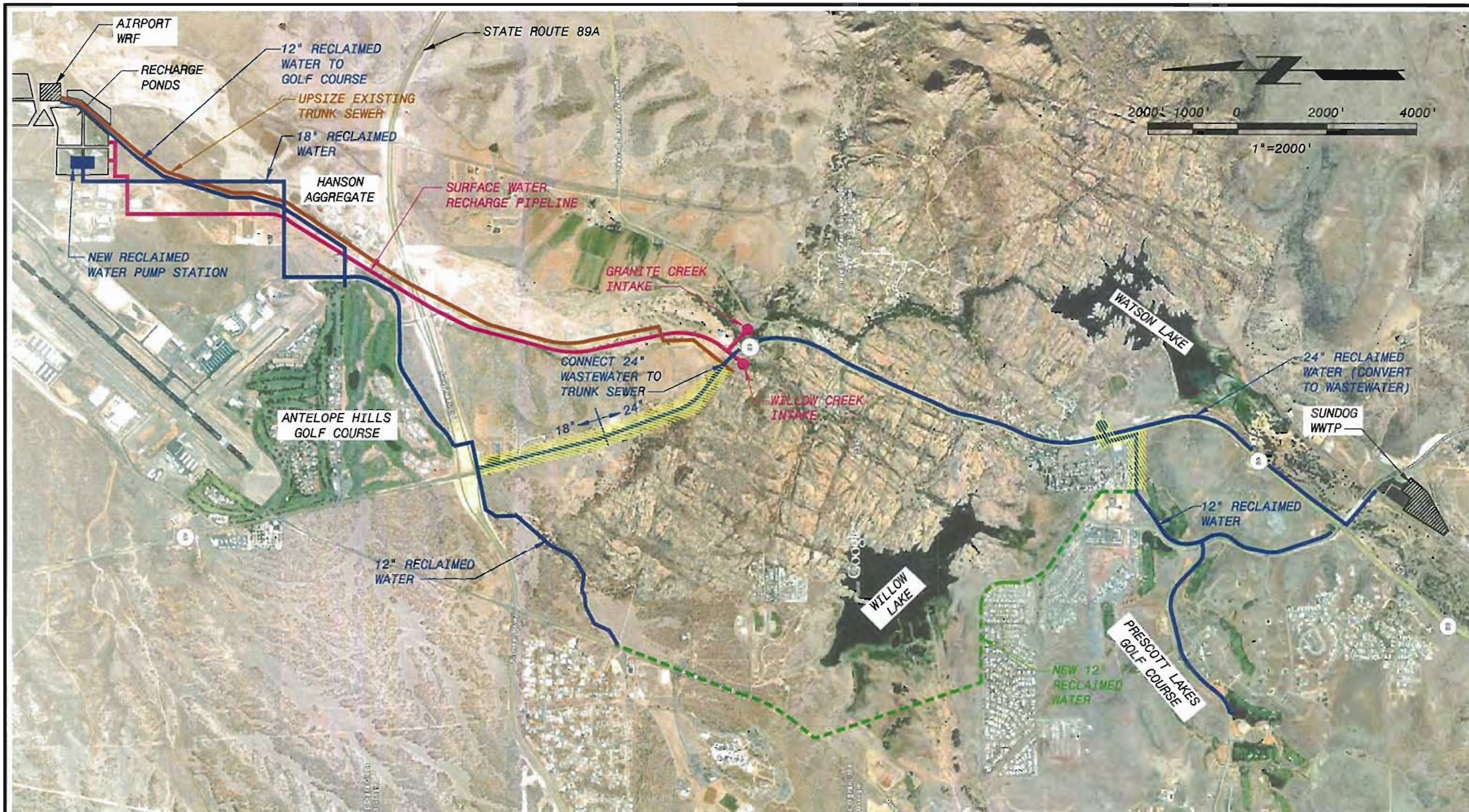


FIGURE 6.1
ALTERNATIVE #1 - CONVERT RECLAIMED WATER TRANSMISSION PIPELINE TO THE WILLOW CREEK INTAKE; THEN UPSIZE TRUNK SEWER TO THE AIRPORT WRF

water pipeline. In addition, the existing 12-inch reclaimed water branch line that goes west through Rifle Ranch needs to be extended around Willow Lake to the Prescott Lakes Golf Course. At the Sundog WWTP, screening and grit removal will continue followed by a new flow equalization basin to store wet weather flows above 10.8 mgd. A new wastewater pipeline will connect the flow equalization basin to the existing (converted) reclaimed water pipeline at the effluent storage ponds.

Alternative No. 2 is similar to Alternative No. 1, except that the existing 24-inch reclaimed water transmission pipeline along SR 89 is rehabilitated from the plant to the existing Prescott Lakes Pump Station on SR 89 and replaced with new sewer piping from this point to the vicinity of the Willow Creek Intake. This alternative is shown in Figure 6.2. By maintaining the existing reclaimed water pipe segment from the Prescott Lakes Pump Station to the Willow Creek Intake, this pipe can convey reclaimed water to the Prescott Lakes Pump Station without the need for a new 12-inch reclaimed water pipeline around Willow Lake, saving considerable capital cost.

Both alternatives eliminate gravity feed of reclaimed water to end users from the Sundog WWTP reclaimed water transmission pipeline. All reclaimed water must be conveyed from the Airport WRF with a new pumping station. Figure 2.2 summarized the reclaimed water demands to three major end users of reclaimed water. The Antelope Hills Golf Course currently receives reclaimed water by gravity from the reclaimed water transmission pipeline and from a pump station at the Airport WRF. For this feasibility analysis, it is assumed that the gravity flows to the Antelope Hills Golf Course, the Prescott Lakes Golf Course, and Hanson Aggregate will now be furnished through a new reclaimed water pump station near the Airport WRF. The reclaimed water demands during 2009 furnished by the reclaimed water transmission pipeline were as follows:

- Annual average flow rate = 0.73 mgd
- Maximum month flow rate = 1.41 mgd
- Peak day flow rate = 2.50 mgd

This analysis assumes three pumps rated at 1.25 mgd each and a total dynamic head of 450 feet with 150 hp motors to accommodate these demands. The capital cost and operating costs for this pump station are included for both alternatives.

The capital cost associated with each alternative is summarized in Table 6.1 below, excluding electrical, instrumentation & control, HVAC, and contingencies. There is very little difference between these alternatives in terms of operating costs. All alternatives require pumping of all reclaimed water to end users. Therefore, Alternative No. 2 is recommended for planning purposes, since this represents the lowest capital cost alternative.

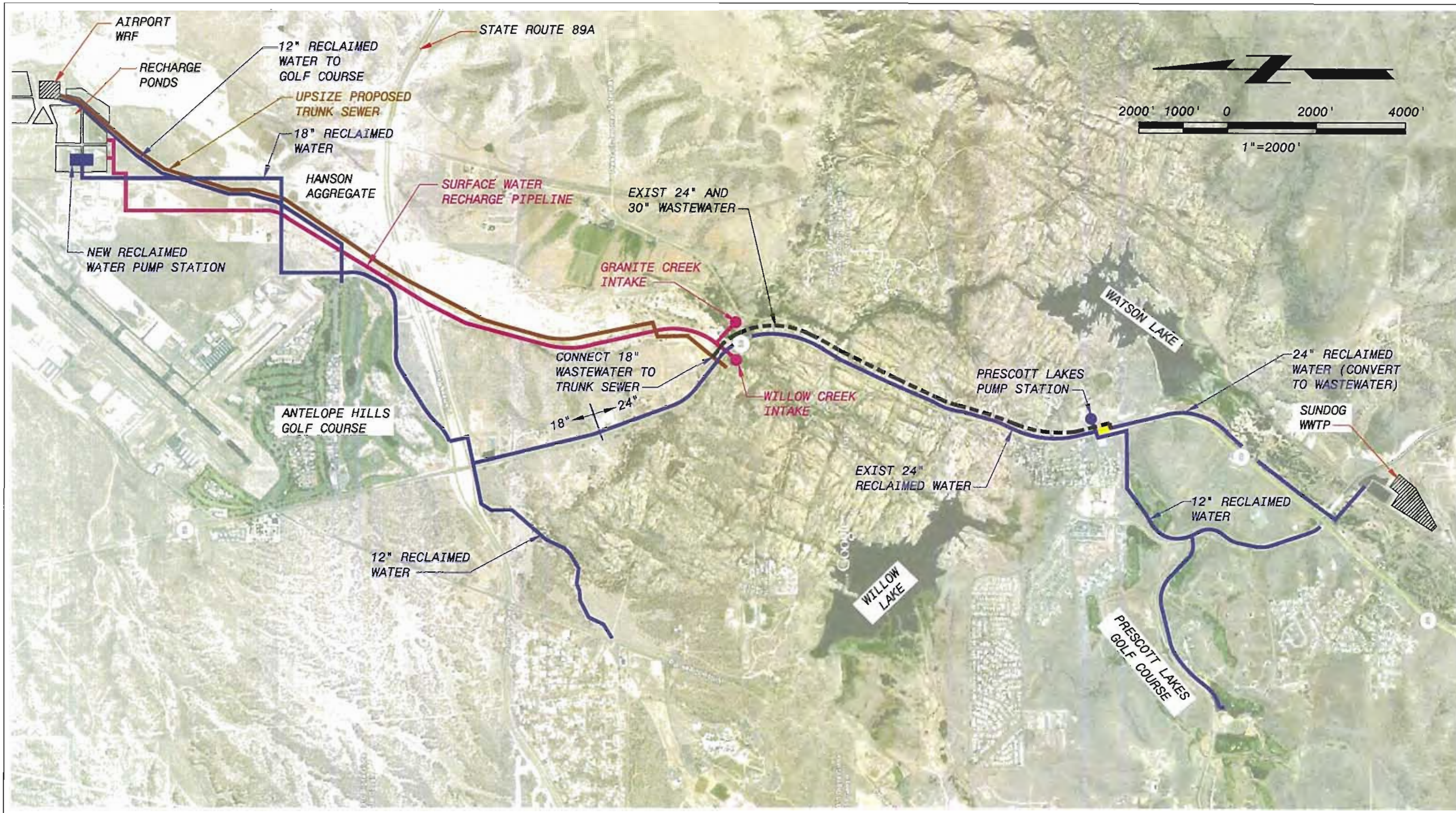


FIGURE 6.2

ALTERNATIVE #2 - CONVERT RECLAIMED WATER TRANSMISSION PIPELINE TO PRESCOTT LAKES PS; INSTALL NEW PIPELINE TO THE WILLOW CREEK AREA; THEN UPSIZE TRUNK SEWER TO THE AIRPORT WRF

Table 6.1 Capital Cost Comparison – Alternatives for Conveying Wastewater to the Airport WRF
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Facilities Required	Capital Cost Estimate	
	Alternative No. 1	Alternative No. 2
Rehabilitate Reclaimed Water Piping from Sundog to Willow Creek Intake	$4,300,000	NA
Rehabilitate Reclaimed Water Piping from Sundog to SR 89; Install new 18”/24” Wastewater to Willow Creek Intake	NA	$1,897,000
Upsize Trunk Sewer from Willow Creek Intake to the Airport WRF	$990,000	$990,000
New Reclaimed Water Pump Station at the Airport WRF	$500,000	$500,000
New 12-inch Reclaimed Water Pipeline from Airport to Intersection of 89/89-A	NA	NA
Pipeline Tunnels at 89 and Pioneer Parkway	NA	NA
New 12-inch Reclaimed Water Pipeline to Prescott Lakes Golf Course	$1,680,000	NA
Totals =	**$7,470,000**	**$3,390,000**

7.0 Sundog WWTP Improvements

For centralized treatment at the Airport WRF, it is assumed that the existing screening and grit removal facilities would remain in place at the Sundog WWTP, followed by new flow equalization facilities to store peak wet weather flows greater than 10.8 mgd. The total volume required for flow equalization is 9 million gallons (MG) and this was determined with recent wet weather flow data in TM No. 4. Continued screening and grit removal are recommended due to potential periods of low velocity in the converted reclaimed water transmission pipeline. The new flow equalization facilities would require a cover, ventilation, odor control and pumping facilities. All other existing facilities would not be required and all treatment beyond preliminary treatment for screenings and grit removal would be eliminated. Septage and grease would be diverted to the Airport WRF in lieu of treatment at the Sundog WWTP and there would be no need for effluent storage ponds. The new flow equalization facilities would be connected by pipeline to the existing reclaimed water pipeline (converted to wastewater service). The majority of the site could potentially be re-developed by the City while maintaining a buffer zone around the preliminary treatment and flow equalization facilities. However, no cost associated with demolition or re-development is included in this analysis. Table 7.1 gives the approximate capital costs for eliminating treatment at the Sundog WWTP with this approach.

**Table 7.1 Capital Cost to Eliminate Treatment at the Sundog WWTP
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis**

Item		Cost
Flow Equalization Basin, Odor Control & Pumping		$ 5,555,000
New Wastewater Piping		$ 330,000
	Subtotal	**$ 5,885,000**
Electrical (20%)		$ 1,177,000
Instrumentation & Control (15%)		$ 883,000
General Requirements (15%)		$ 883,000
	Subtotal	**$ 8,882,000**
Contingencies (20%)		$ 1,766,000
	Subtotal	**$ 10,648,000**
Contractor Overhead & Profit (15%)		$ 1,597,000
	Subtotal	**$ 12,245,000**
Tax (5%)		$ 612,000
	Total Probable Construction Cost	**$ 12,857,000**

8.0 Airport WRF Improvements

The Airport WRF centralized treatment alternative concept assumes that treatment for all wastewater flows (and the associated biosolids) generated in the City is concentrated at the Airport WRF site. This section summarizes the evaluation of the required improvements at the Airport WRF site to achieve the goal of centralizing treatment at one location, while still maintaining a first phase of improvements that allows the City to gradually transition from a two-plant approach to a centralized treatment approach.

8.1 Design Wastewater Flows

The combined buildout annual average day flow (AADF) for the Airport WRF and Sundog WWTP tributary areas is 14.8 mgd (City of Prescott Wastewater Master Plan). For the purposes of this technology assessment and site master planning project, the buildout capacity was established at 15 mgd (9.6 mgd from Airport WRF and 5.4 mgd from Sundog WWTP).

The wastewater flow peaking factors for the Airport WRF and the Sundog WWTP were developed in Technical Memoranda No. 3A and 3S, and are based on historical wastewater flow data between 2006 and 2009 for each plant. For the evaluation of the centralized treatment alternative at buildout, the flows to each plant were combined assuming that maximum month average day, peak day, and peak hour flows for each plant's existing service area coincide when combined at the Airport WRF.

Table 8.1 presents the design wastewater flow parameters used for the evaluation of the centralized treatment alternative in this TM No. 6.

Table 8.1 Buildout Design Wastewater Flows and Peaking Factors
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Flow Criteria	Airport WRF Buildout Flow, mgd(1)	Sundog WWTP Buildout Flow, mgd (1,2)	Combined Buildout Flow at Airport WRF, mgd (1,3)	Combined Hydraulic Peaking Factor (1,3)
Annual Average Day Flow	9.6	5.4	15.0	1.00
Maximum Month Average Day	13.4	10.8	24.2	1.62
Peak Day	19.2	10.8	30.0	2.00
Peak Hour	28.8	10.8	39.6	2.64

Notes:
(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.
(2) Based on the assumption that flow equalization facilities and/or collection system improvements result in peaking factors no greater than 2.0 for the Sundog WWTP service area flows.
(3) Based on the assumption that peak flows for the Airport WRF and Sundog WWTP service areas coincide when combined at the Airport WRF.

8.1.1 Phase 1 Design Flows

The capacity for each phase of the master planned capacity at the Airport WRF was established at 3.75 mgd (four treatment trains total). This capacity was established based on discussions with the City in several workshops, and is marginally larger than the Phase 1 capacity of 3.2 mgd originally identified in Technical Memorandum No. 5A. Several advantages of a Phase 1 capacity of 3.75 mgd were identified:

- A Phase 1 capacity of 3.75 mgd provides the City with the flexibility to implement a Phase 1 at the Airport WRF that is compatible with a centralized treatment approach (ultimate capacity of 15 mgd) or with a decentralized treatment approach (ultimate capacity of 9.6 mgd).

- A Phase 1 capacity of 3.75 mgd provides additional treatment capacity beyond the permitted capacity of the existing Airport WRF (2.2 mgd). This additional capacity provides the City with the opportunity to develop a long-term financial plan with adequate timing for funding the next major plant expansion after the Phase 1 expansion is completed.

- Ultimately, four treatment trains of 3.75 mgd are more cost-effective than five treatment trains of 3 mgd, due to economy of scale for construction and operation. Four trains of 3.75 mgd (instead of five trains of 3 mgd) also provide a more efficient utilization of the available space at the plant site, minimizing the potential need to reduce existing recharge basin capacity.

8.1.2 Phase 1 Design Peaking Factors

The wastewater flow peaking factors for evaluation of Phase 1 of the centralized treatment alternative are based on the assumption that the majority of the flow for Phase 1 will be generated at the Airport WRF service area. Therefore, the flow peaking factors developed in Technical Memorandum No. 3A for the Airport WRF were assumed for Phase 1 of the centralized treatment alternative, and are based on historical wastewater flow data at the Airport WRF between 2006 and 2009. Table 8.2 presents the design wastewater parameters used for the evaluation of the first phase of the centralized treatment alternative in this Technical Memorandum No. 6.

Table 8.2 Phase 1 Design Wastewater Flows and Peaking Factors Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona Centralized Treatment Feasibility Analysis		
Flow Criteria	**Phase 1 Flow, mgd**	**Hydraulic Peaking Factor(1)**
Annual Average Day Flow	3.75	1.0
Maximum Month Average Day	5.25	1.4
Peak Day	7.50	2.0
Peak Hour	11.25	3.0

Note:

(1) Based on historical data analysis between January 2006 and April 2009. All peaking factors are relative to the annual average day flow.

8.2 Design Wastewater Loads

The wastewater constituent concentrations used for evaluation of the centralized treatment alternative were developed in Technical Memoranda No. 3A and 3S, and are based on historical wastewater quality data between 2006 and 2009 for each plant. For the evaluation of the centralized treatment alternative at buildout, the flows and loads to each plant were combined assuming that maximum month average day loadings for each plant's existing service area coincide when combined at the Airport WRF.

Table 8.3 presents the design wastewater parameters used for the evaluation of the centralized treatment alternative in this Technical Memorandum No. 6.

Table 8.3 Design Wastewater Characteristics - Buildout
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Design Parameter	Units	Airport WRF		Sundog WWTP		Combined Loadings at Airport WRF	
		Annual Average Day	Maximum Month Average Day(1)	Annual Average Day	Maximum Month Average Day(2)	Annual Average Day	Maximum Month Average Day(3)
Flow	mgd	9.6	13.4	5.4	10.8	15.0	24.2
BOD	mg/L	322	383	373	313	340	352
TSS	mg/L	504	633	402	329	467	498
TKN	mg/L	34.6	41.2	39.5	33.1	36.4	37.6
Ammonia N	mg/L	29.5	35.1	31.5	26.4	30.2	31.2
Alkalinity	mg/L	250	250	295	295	266	270
Temperature	°C	18.4	12.4	19.6	14.9	18.8	13.5

Notes:

(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).

(2) Based on the assumption that the winter average concentrations coincide with the maximum month flow.

(3) Based on the assumption that the maximum month loads (ppd) of the Airport WRF and Sundog WWTP service areas coincide during winter conditions.

8.2.1 Design Wastewater Loads

The wastewater loadings for evaluation of Phase 1 of the centralized treatment alternative are based on the assumption that the majority of the wastewater flow for Phase 1 will be generated at the Airport WRF service area. Therefore, the design wastewater characteristics developed in Technical Memorandum No. 3A for the Airport WRF were assumed for Phase 1 of the centralized treatment alternative, and are based on historical wastewater quality data at the Airport WRF between 2006 and 2009. Table 8.4 presents the design wastewater parameters used for the evaluation of the first phase of the centralized treatment alternative in this Technical Memorandum No. 6.

Table 8.4 Design Wastewater Characteristics
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Design Parameter	Unit	Annual Average Day	Maximum Month Average Day (1)
Flow	mgd	3.75	5.25
BOD	mg/L	322	383
TSS	mg/L	504	633
TKN	mg/L	34.6	41.2
Ammonia N	mg/L	29.5	35.1
Alkalinity	mg/L	250	250
Temperature	°C	18.4	12.4

Note:
(1) Based on the assumption that the maximum month load (ppd) coincides with the maximum month flow (mgd).

8.3 Airport WRF Improvements

Based on the alternative treatment technologies evaluations presented in Technical Memoranda No. 5A and 5S, the Conventional (MLE) Treatment Alternative was used for the detailed evaluation of the centralized treatment alternative at the Airport WRF. The centralized treatment alternative evaluation was based on identifying the facilities required at buildout (15 mgd) as well as Phase 1 (3.75 mgd) and Phase 2 (7.5 mgd). The detailed evaluation process included the following steps:

- Conceptual process design to determine facilities required.
- Process unit sizing and evaluation of treatment performance using process modeling.
- Development of preliminary site layouts.
- Development of planning-level cost estimates for capital and operations and maintenance costs.

8.3.1 Process Design Criteria

The processes for liquids and solids treatment for the centralized treatment alternative are described below. The general approach for the conceptual process design was to base the unit process sizing on the requirements for buildout, while incorporating as many of the existing facilities as possible into the first phase of the master planned facilities.

8.3.1.1 Preliminary Treatment

Screening was based on the addition of new, in-channel mechanical bar screens (step screens) including a bypass with a manual screen. The sizing criteria for the screens is based on the wastewater velocity through the bar openings, which is determined by the width of the channel and the operating water depth. As the plant influent flow increases towards buildout, the operating depth in the channels can be increased to allow using the same screen units from Phase 1 to buildout. The screen sizing criteria was based on this approach. Utilization of the existing screen beyond its rated capacity of 2.4 mgd is not feasible due to the channel depth and existing hydraulics.

For costing and site layout purposes, grit removal was based on the assumption of mechanical vortex units in concrete basins, a common approach in municipal treatment plants which is consistent with the existing technology used at the City’s facilities. It should be noted that a detailed evaluation of both screening and grit removal technologies should be part of a preliminary design effort.

The number of screening and grit removal units assumed at Phase 1 and buildout are summarized in Table 8.5.

8.3.1.2 Primary Treatment

Primary treatment reduces mainly BOD and TSS from the plant influent loadings. Primary treatment was incorporated as part of the process design in order to reduce the aeration basin volume and process air required for secondary treatment. Circular clarifiers and a primary sludge pump station were assumed for costing and site layout purposes.

Primary treatment was not included for Phase 1 conditions. Primary clarification produces unstabilized primary sludge, and the Airport WRF facilities do not currently have sludge stabilization facilities (i.e., digesters). Therefore, it was assumed that primary treatment would be constructed together with digestion facilities at Phase 2 at the earliest to postpone the significant capital investment required for those facilities.

Table 8.5 Airport WRF Centralized Treatment Alternative Facilities Summary
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Unit Process	Facilities Required at Phase 1 (3.75 mgd)	Facilities Required at Buildout (15 mgd)
Coarse Screening	• 1 mechanical bar screen (duty) • 1 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control	• 2 mechanical bar screens (duty) • 2 washer/compactors • 1 manual bar screen (redundant) • Building (3,200 sf) with odor control
Grit Removal	• 1 mechanical vortex unit, concrete basins	• 3 mechanical vortex units, concrete basins
Primary Sedimentation	N.A.	• 4 units, 80-ft diameter with dome covers and clarifier mechanism
Primary Sludge Pump Station	N.A.	• Pump station structure • Progressive Cavity Pumps: 2 duty + 1 standby, 150 gpm each • Primary scum pumps: 2 units, 160 gpm each
Activated Sludge Treatment Basins	• 2 trains, 3.6 MG per train (7.2 MG total) • Submersible mixers (27 HP), 2 per train • Fine bubble diffuser system • Mixed liquor return pumps: 9,100 gpm/basin	• 4 trains, 3.6 MG per train (14.4 MG total) • Submersible mixers (27 HP), 2 per train • Fine bubble diffuser system • Mixed liquor return pumps, 21,000 gpm/train
Blower Building	• Centrifugal blowers • 3 units (one redundant), 5,000 scfm each • Blower building (1,200 sf)	• Centrifugal blowers • 5 units (one redundant), 6,500 scfm each • Blower building (1,800 sf)
Secondary Sedimentation	• 2 units (one redundant at AADF loads) • 100-ft diameter, 15-ft side water depth	• 6 units (one redundant at AADF loads) • 100-ft diameter, 15-ft side water depth

Table 8.5 Airport WRF Centralized Treatment Alternative Facilities Summary
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

Unit Process	Facilities Required at Phase 1 (3.75 mgd)	Facilities Required at Buildout (15 mgd)
RAS/WAS Pumping	• Wet well with submersible centrifugal pumps. • RAS: 2 pumps (one redundant); 2,800 gpm each • WAS: 2 units (one redundant); 250 gpm each • Secondary scum pumps, 2 pumps	• Wet well with submersible centrifugal pumps. • RAS: 4 pumps (one redundant); 4,200 gpm each • WAS: 3 units (one redundant); 800 gpm each • Secondary scum pumps, 4 pumps
Tertiary Filtration	• Cloth media disk filters in concrete basins. • 3 units (one redundant), total filtration area: 1,938 sf	• Cloth media disk filters in concrete basins. • 10 units (one redundant), total filtration area: 6,456 sf
Disinfection	• UV disinfection, open channel low-pressure high-output. • 1 channel, 4 banks in channel (one redundant bank in channel).	• UV disinfection, open channel low-pressure high-output. • 4 channels, 4 banks per channel (one redundant bank per channel).
Effluent Pumping	• Wet well volume; 25,000 cf • 2 vertical turbine pumps (one redundant); 4,000 gpm each	• Wet well volume; 25,000 cf • 5 vertical turbine pumps (one redundant); 6,900 gpm each
Solids Handling	• One additional centrifuge (80 to 120 gpm) in existing building • Use existing 60-ft secondary clarifier for WAS thickening	• 3 thickening units (one redundant); 500 gpm • 3 dewatering units (one redundant); 200 gpm • Solids handling building (16,991 sf)
Digestion	N.A.	• 5 digesters, 85 ft diameter, 25 ft SDW. • Boiler building, flares, mixing system

The size and number of primary clarifier units at Phase 1 and buildout are summarized in Table 8.5. Detailed process calculations with sizing criteria such as surface overflow rate, BOD and TSS removal efficiencies are included in Appendix A.

8.3.1.3 Secondary Treatment

The MLE activated sludge treatment process includes compartmentalized aeration basins with two anoxic zones and four aeration zones, arranged in a two-pass configuration. Low-head mixed liquor return pumps provide the recycle of nitrates from the last aeration zone back to the first anoxic zone. Submersible mixers were assumed for mixing in the anoxic zones. Membrane disc, fine bubble diffusers were assumed in order to provide efficient aeration and minimize the required blower size.

Centrifugal blowers in a dedicated building were assumed for costing and site layout purposes. The blower building was assumed to expand from Phase 1 to build out in order to minimize footprint and cost for Phase 1.

Circular secondary clarifiers provide solids-liquid separation of the mixed liquor suspended solids from the aeration basins. The larger clarifier size required for Phase 1 and buildout as compared to the existing secondary clarifier (100 ft versus 60 ft), and the site layout prevented reutilization of the existing clarifier for final clarification (see solids handling for reutilization of existing secondary clarifier).

A new return activated sludge (RAS) and waste activated sludge (WAS) pump station was assumed for Phase 1 and buildout. For costing and layout purposes, the pump station was assumed to have a wet well with submersible pumps. The wet well was assumed to be constructed in Phase 1, with additional pumps to provide sufficient capacity for buildout.

The design criteria for the aeration basins, blower building, and secondary clarifiers at Phase 1 and buildout are summarized in Table 8.5. Detailed process calculations with sizing criteria such as mixed liquor suspended solids, solids retention time, surface overflow rates, clarifier safety factors, process air requirements, RAS and WAS flows are included in Appendix A.

8.3.1.4 Tertiary Treatment

Based on the evaluation and recommendations presented in TM No. 7 - Tertiary Filtration Evaluation, the liquid treatment alternatives analyzed in this TM No. 6 assume disc filter technology. The disc filters considered would require new basins, and due to site layout considerations reusing the existing traveling bridge filter structure was not considered.
For disinfection, evaluation of alternatives under this TM No. 6 are based on UV disinfection technology. This approach is based on the fact that UV is the existing technology used at both the Airport WRF and the Sundog WWTP, and that assuming UV technology provides a contingent cost for planning purposes. In-channel UV technology was assumed for this evaluation based on other experiences with conventional MLE projects.

Other disinfection alternatives are certainly available to the City, such as chlorine and ozone disinfection. A detailed evaluation of disinfection technologies is a preliminary design task that should consider factors such as capital and operational costs, disinfection by-product formation, reliability, redundancy, among others. The detailed evaluation of disinfection technologies is not included in the current project, but should be performed as part of the facilities design.

The design criteria for the tertiary filters and disinfection at Phase 1 and buildout are summarized in Table 8.5. Detailed process calculations with sizing criteria such as hydraulic loading rates, number of units, and filtration area are included in Appendix A.

8.3.1.5 Effluent Pumping to Recharge Basins

For the purposes of this study, vertical turbine pumps in a wet well were assumed. The wet well was assumed to be constructed in Phase 1, with additional pumps to provide sufficient capacity for buildout. The design criteria for the effluent pump station are summarized in Table 8.5.

8.3.1.6 Solids Handling and Stabilization

Anaerobic digestion to achieve Class B biosolids quality was assumed as the sludge stabilization process for the ultimate conventional MLE process alternative. Aerobic digestion was not considered for the ultimate MLE process due to the significant capital and operating costs associated with this alternative. More detailed discussion of biosolids alternatives is given in TM No. 9.

Anaerobic digestion was not considered for Phase 1 due to the relatively large capital costs associated with digestion facilities. Therefore, landfill disposal of unstabilized dewatered sludge is assumed for Phase 1 at the Airport WRF.

Solids thickening was assumed upstream of the ultimate anaerobic digestion process, in order to reduce the volume of solids and therefore the tankage required for the digestion process. For the purposes of this evaluation, gravity belt thickeners were assumed based on current practice at the Sundog WWTP.

Solids dewatering was assumed downstream of the ultimate anaerobic digestion process, in order to reduce the volume of solids for disposal. For the purposes of this evaluation, centrifuge dewatering was assumed based on current practice at the Airport WRF. For Phase 1, it was assumed that additional dewatering equipment will be installed in the existing building. It was also assumed that the existing secondary clarifier was used to pre-thicken solids before they are sent to the dewatering centrifuges, in order to avoid overloading the centrifuges.

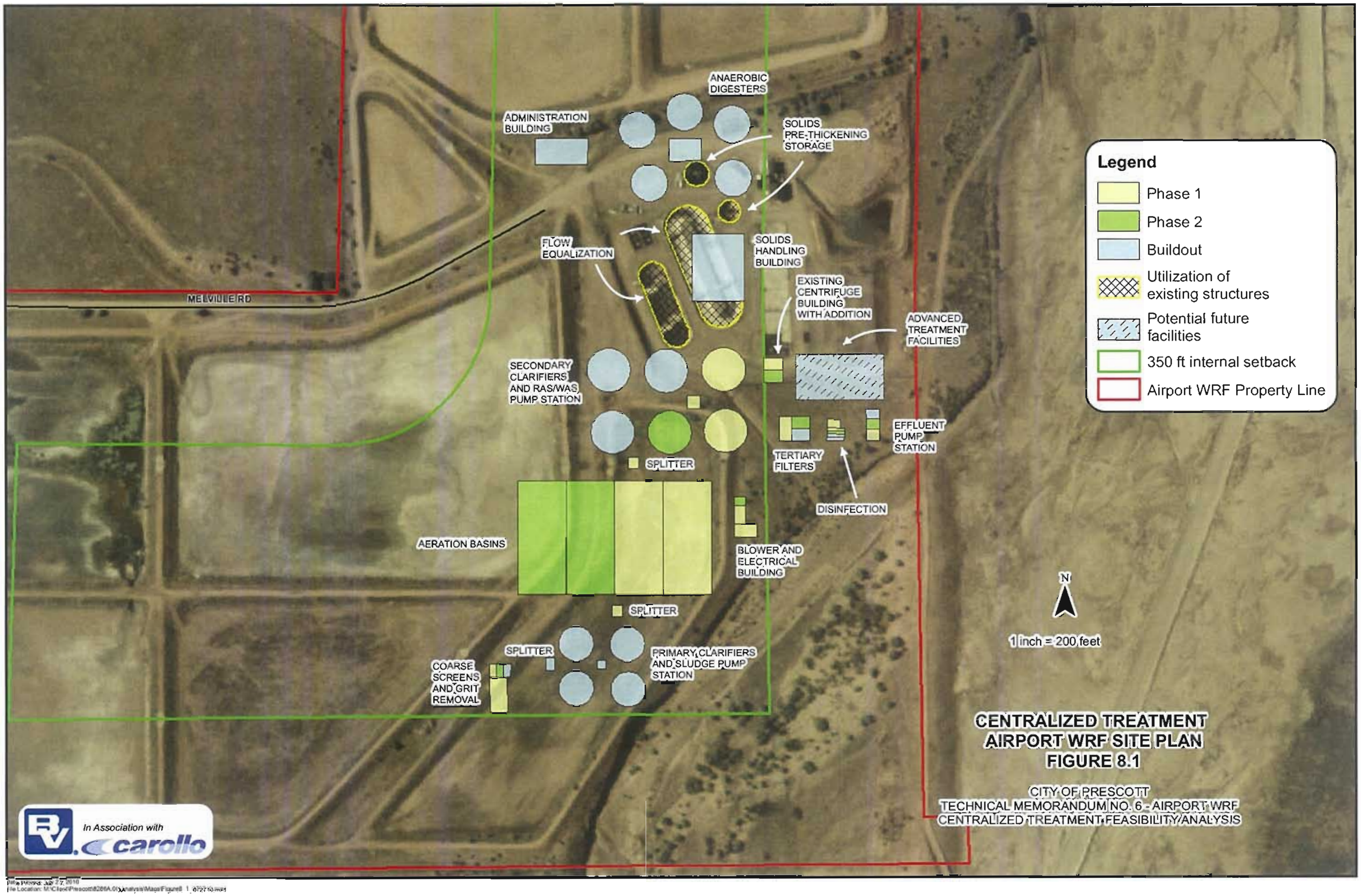
As mentioned for other unit processes, a detailed evaluation of the different solids handling technologies available to the City (rotary drum thickeners, centrifuge thickening, belt filter press dewatering, etc.) is a preliminary design task that should determine the thickening and dewatering technologies for the actual design for the facilities, but is not included as part of this project.

8.3.2 Design Criteria Summary

Table 8.5 summarizes the required facilities for the conventional treatment alternative at a buildout flow of 15 mgd, and a Phase 1 flow of 3.75 mgd. Also listed in Table 8.5 are the assumptions on the type of equipment or process that were made for the purposes of costing and layout. It should be noted that selection of specific equipment types or process alternatives should be further evaluated during preliminary design. A process model output summary is included in Appendix A with specific design criteria for each of the unit processes, including operating parameters and expected effluent quality.

8.3.3 Site Plan

Figure 8.1 presents the preliminary site plan for the conventional treatment alternative. The layout is based on the conservative assumption that no waivers are obtained from adjacent property owners. Therefore, all odor-producing facilities are shown within the 350-feet internal setback from the property boundary. The layout assumes that the footprint occupied by the effluent recharge basin in the southeast end of the site is used for the required treatment facilities. Another assumption is that the footprint currently occupied by the older oxidation ditch and the existing secondary clarifiers is reclaimed for the solids treatment and handling facilities.


ANAEROBIC DIGESTERS
ADMINISTRATION BUILDING
SOLIDS PRE-THICKENING STORAGE
FLOW EQUALIZATION
SOLIDS HANDLING BUILDING
EXISTING CENTRIFUGE BUILDING WITH ADDITION
ADVANCED TREATMENT FACILITIES
MELVILLE RD
SECONDARY CLARIFIERS AND RAS/WAS PUMP STATION
EFFLUENT PUMP STATION
TERTIARY FILTERS
SPLITTER
DISINFECTION
AERATION BASINS
BLOWER AND ELECTRICAL BUILDING
SPLITTER
SPLITTER
PRIMARY CLARIFIERS AND SLUDGE PUMP STATION
COARSE SCREENS AND GRIT REMOVAL
Legend
Phase 1
Phase 2
Buildout
Utilization of existing structures
Potential future facilities
350 ft internal setback
Airport WRF Property Line
N
1 inch = 200 feet
CENTRALIZED TREATMENT
AIRPORT WRF SITE PLAN
FIGURE 8.1
CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 6 - AIRPORT WRF
CENTRALIZED TREATMENT FEASIBILITY ANALYSIS
In Association with carollo

9.0 Decentralized Versus Centralized Treatment Comparison

9.1 Economic Comparison

Capital and operating costs for continued independent treatment at the Sundog WWTP and Airport WRF were developed and presented in Technical Memoranda 5S and 5A. The costs are summarized and totaled in Table 9.1 which presents the ultimate combined cost at build-out for distributed treatment at the two existing facilities. Detailed capital and operating costs are given in TM No. 5A and TM No. 5S.

Table 9.2 summarizes the total ultimate program costs (capital and operating) for centralized treatment of build-out flows at the Airport WRF. Detailed capital and operating costs are given in Appendix B of this TM 6.

Table 9.1 Capital/Operating Cost and Present Worth for Decentralized Treatment at Sundog WWTP and Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP (5.4 mgd) (Build-out)	75.1	2.60	110.75
Airport WRF (9.6 mgd) (Build-out)	115.4	3.63	160.63
	190.5	6.23	271.38

Note:
[1] 20 yr Present Worth @ 5% interest.

Table 9.2 Capital/Operating Cost and Present Worth for Centralized Treatment at Airport WRF
Technical Memorandum No. 6 – City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Capital Cost, $ mil	Operating Cost $ mil/yr	Present Worth,[1] $ mil
Sundog WWTP	10.4	0.5	17.27
Conveyance	3.4	0.2	6.15
Airport WRF (15 mgd)	160.7	4.73	225.66
	174.5	5.43	249.08

Note:
[1] 20 yr Present Worth @ 5% interest.

9.2 Non-Economic Evaluation

In addition to the economic (present worth) comparison for centralized treatment, non-economic factors were considered. The following non-economic issues are considered and defined below:

1. Effluent Quality & Permit Compliance – Assessment of the ability for the alternative to meet all permit limits and maintain required effluent quality.

2. Aging Infrastructure – Assessment of the alternative relative to risk of reliance on aging infrastructure.

3. Operational Complexity – Assessment for the overall operational complexity of the alternative.

4. Staffing Training Requirements – Assessment of staffing and staff training for each alternative.

5. Ease of Maintenance – Assessment of maintaining each alternative.

Table 9.3 summarizes the non-economic comparison of alternatives. Each issue is given a weighting factor in terms of the overall importance of the issue. Then each issue is evaluated with a rating given (10 = best and 1 = worst). The score for each issue is the product of the rating and weighting factor. The individual scores are totaled to provide an overall score for each alternative (highest total is best).

Based on this feasibility analysis, eliminating treatment at the Sundog WWTP has a slightly lower present worth cost and a higher non-economic rating than separate expansion of each treatment facility. However, the costs and scores do not strongly favor either alternative.

Additional planning activities that can be taken in order to further evaluate decentralized treatment include:

- Perform a conceptual design for rehabilitation of the existing reclaimed water pipeline to further define alternatives and costs.
- Perform a conceptual designs for the Sundog WWTP and Airport WRF improvements to further develop cost estimates.

Table 9.3 Non-Economic Factor Comparison
Technical Memorandum No. 6 – Airport WRF, City of Prescott, Arizona
Centralized Treatment Feasibility Analysis

	Weighting Factor	Continued Decentralized Treatment at Sundog WWTP and Airport WRF		Centralized Treatment at Airport WRF	
		Raw Score	Weighed Score	Raw Score	Weighed Score
Effluent Quality	x 5	7	35	8	40
Aging Infrastructure	x 4	6	24	9	36
Operational Complexity	x 4	5	20	7	28
Staffing/Training Requirements	x 3	5	15	7	21
Ease of Maintenance	x 4	5	20	7	28
TOTAL			114		153

Note:

1. Comparison of non-economic factors where 10 = best and 1 = worst

10.0 Alternative Phasing and Capital Improvement Plans

10.1 Centralized Treatment Phasing

As discussed, centralized treatment at the Airport WRF would include the following recommended facilities:

1. Sundog WWTP Improvements to address immediate issues:
    - Nitrification/denitrification process control improvements
    - Filter rehabilitation or replacement
    - Temporary centrifuge dewatering facilities
    - Headworks odor control
2. Airport WRF (first phase) 3.75 mgd Expansion.
3. Airport WRF (second phase) 7.5 mgd Expansion (without anaerobic digestion).
4. Sundog WWTP Wastewater Conveyance to the Airport WRF.
    - Wastewater Conveyance Alternative No. 2 (see Section 6.0)
    - Sundog WWTP Flow Equalization Facilities (see Section 7.0)
5. Future Airport WRF phases to reach ultimate 15 mgd capacity.

The first two improvements above are compatible with wither the de-centralized or centralized treatment alternatives. An initial phase capacity of 3.75 mgd is recommended for the Airport WRF to maintain the flexibility to implement centralized treatment. However, sizing the Airport WRF at 3.75 mgd does not dictate the City pursue centralized treatment in the future. Completing these two initial projects will allow time for the City to make a decision on centralized treatment.

The decision point for centralized treatment will occur when the Sundog WWTP reaches its current capacity. As shown in Figure 10.1, the Sundog WWTP is projected to reach its current capacity sometime between 2015 and 2019. Since there is currently little or no growth in the City, it is recommended that the City plan to have the additional treatment capacity in operation by 2019 (conservative growth flow assumption). If actual growth accelerates over the next few years, the timing should be revisited. In approximately Year 2016, the City should make a decision on whether to either expand the Sundog WWTP or eliminate treatment at that location and pursue the centralized treatment approach. For centralized treatment, this will allow time for the City to plan, implement a second phase of treatment capacity at the Airport WRF, to replace treatment at the Sundog WWTP, and Sundog WWTP wastewater flow conveyance and flow equalization facilities.

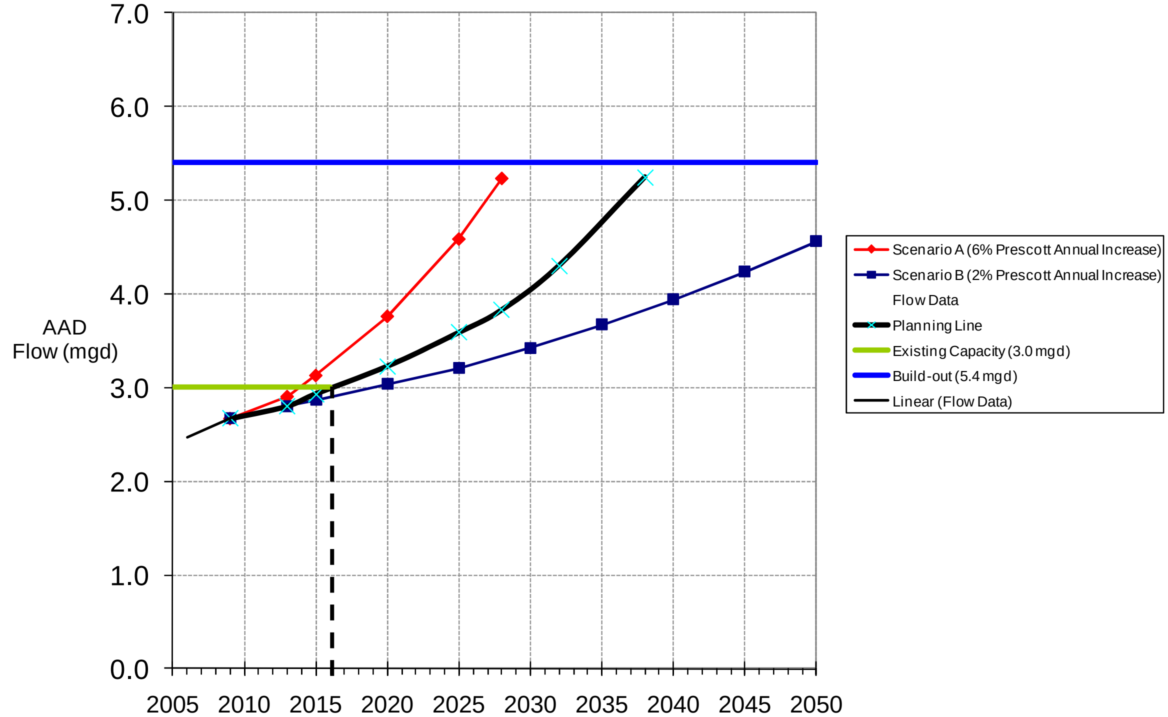


Figure 10.1 Flow Increase Curves –Sundog WWTP

Figure 10.2 presents the range of flow increase curves for total combined centralized flow at the Airport WRF. Projected Phase III and Phase IV plant expansions out to 15 mgd are, as shown.

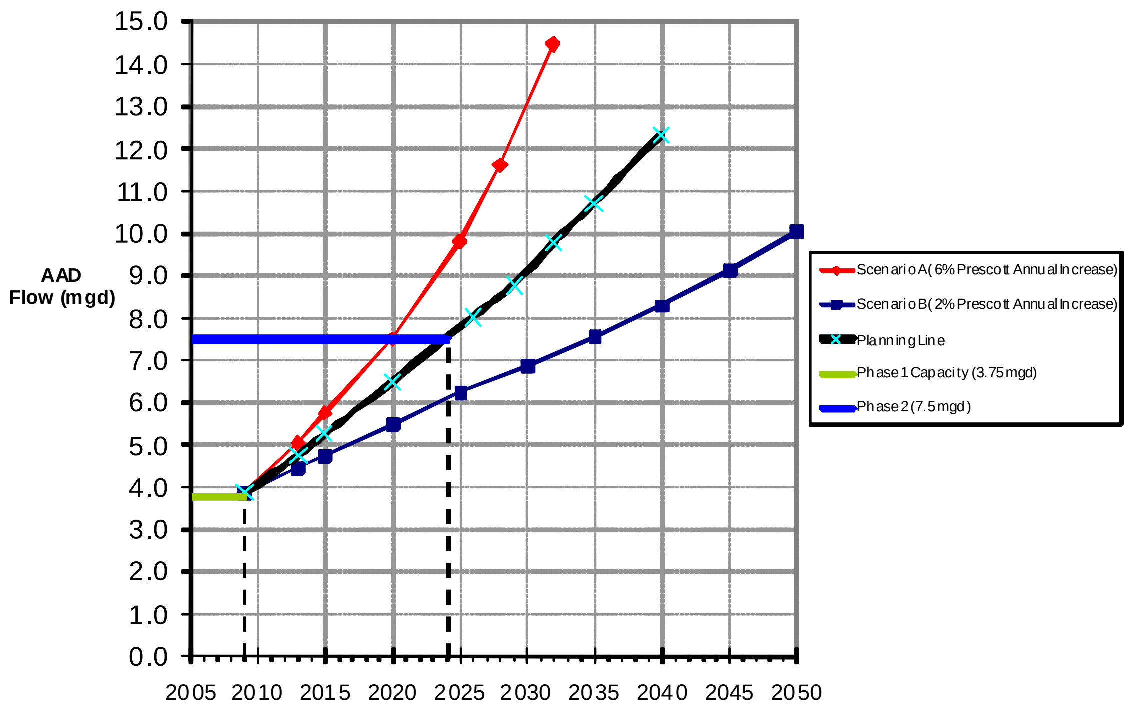


Figure 10.2 Flow Increase Curves – Combined Sundog WWTP and Airport WRF

Figure 10.3 presents a projected 20 year (2010-2030) cash flow for capital improvements for the centralized treatment. The capital costs shown include the projected construction costs plus an allowance of 15% for engineering and administration. All costs are shown in 2010 dollars without inflation. The near term capital improvements (thru 2020) are based on the conservative flow growth curves (2% growth rate) in Figures 10.1 and 10.2. The longer term improvements (2020 – 2030) are based on midpoint growth, between the conservative and aggressive growth curves. If actual growth accelerates in the coming years, this assumption should be revisited. As discussed, the key decision point is centralized treatment versus separate treatment in 2016 which allows enough time to implement required centralized treatment improvements before Sundog WWTP capacity is reached. For this evaluation, it is assumed that all plant expansions at the Airport WRF are implemented without anaerobic digesters.

10.2 Decentralized Treatment Phasing

Figure 10.4 presents a projected 20 year cash flow for capital improvements for maintaining separate treatment at the Sundog WWTP and Airport WRF under the same growth assumptions as for centralized treatment. The key decision points and timing are the same as for the centralized treatment approach. The capital costs include projected construction costs plus an allowance of 15% for engineering and administration. All costs are shown in 2010 dollars without inflation.

The key timing for key decisions are the same as for centralized treatment. The initial improvements are also the same, except that the first phase of the Airport WRF would be 3.2 mgd capacity rather than 3.75 mgd.

10.3 Cumulative Capital Costs

Figure 10.5 illustrates cumulative capital costs over 20 years for both centralized and decentralized treatment.

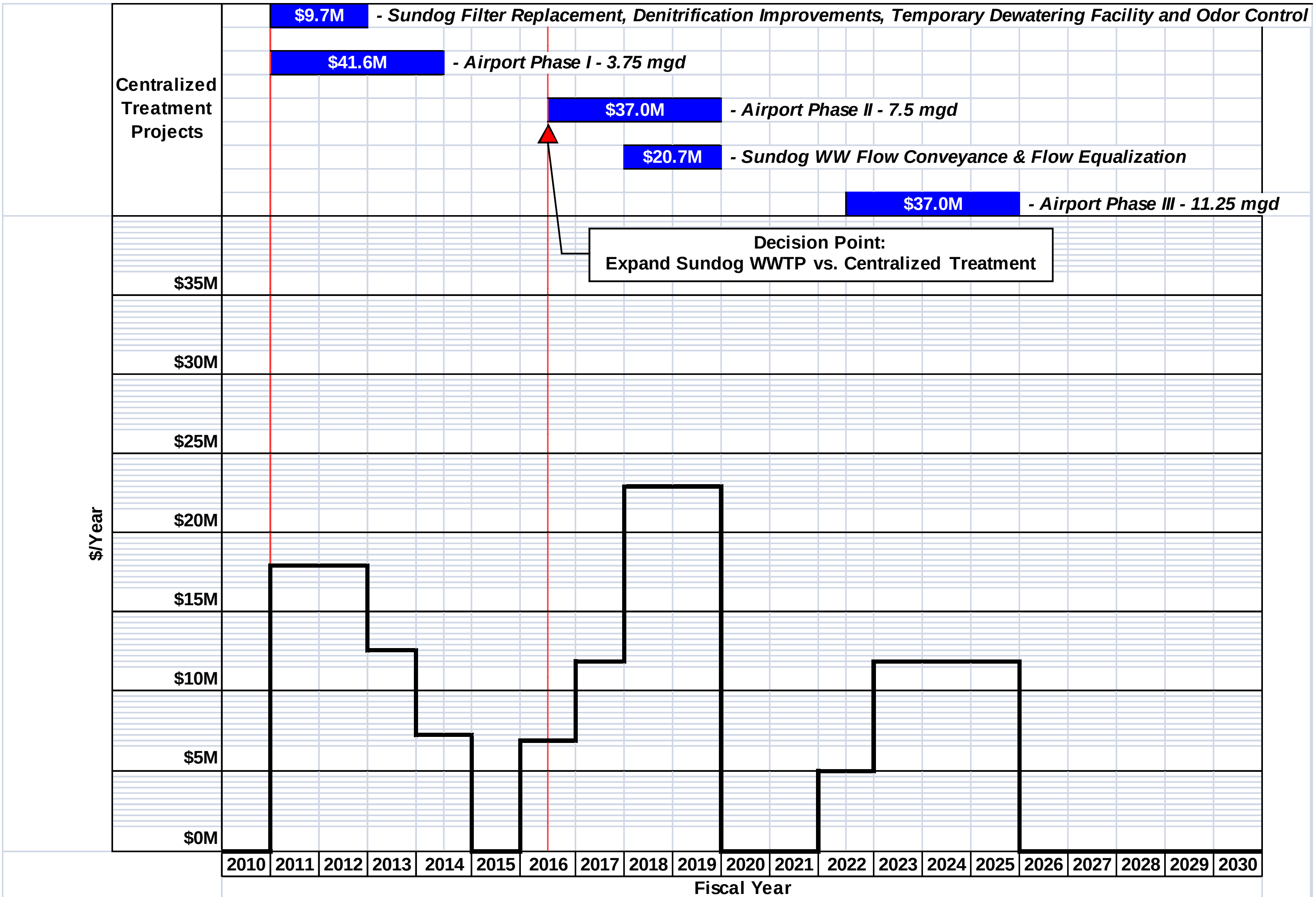


Figure 10.3 Centralized Treatment CIP

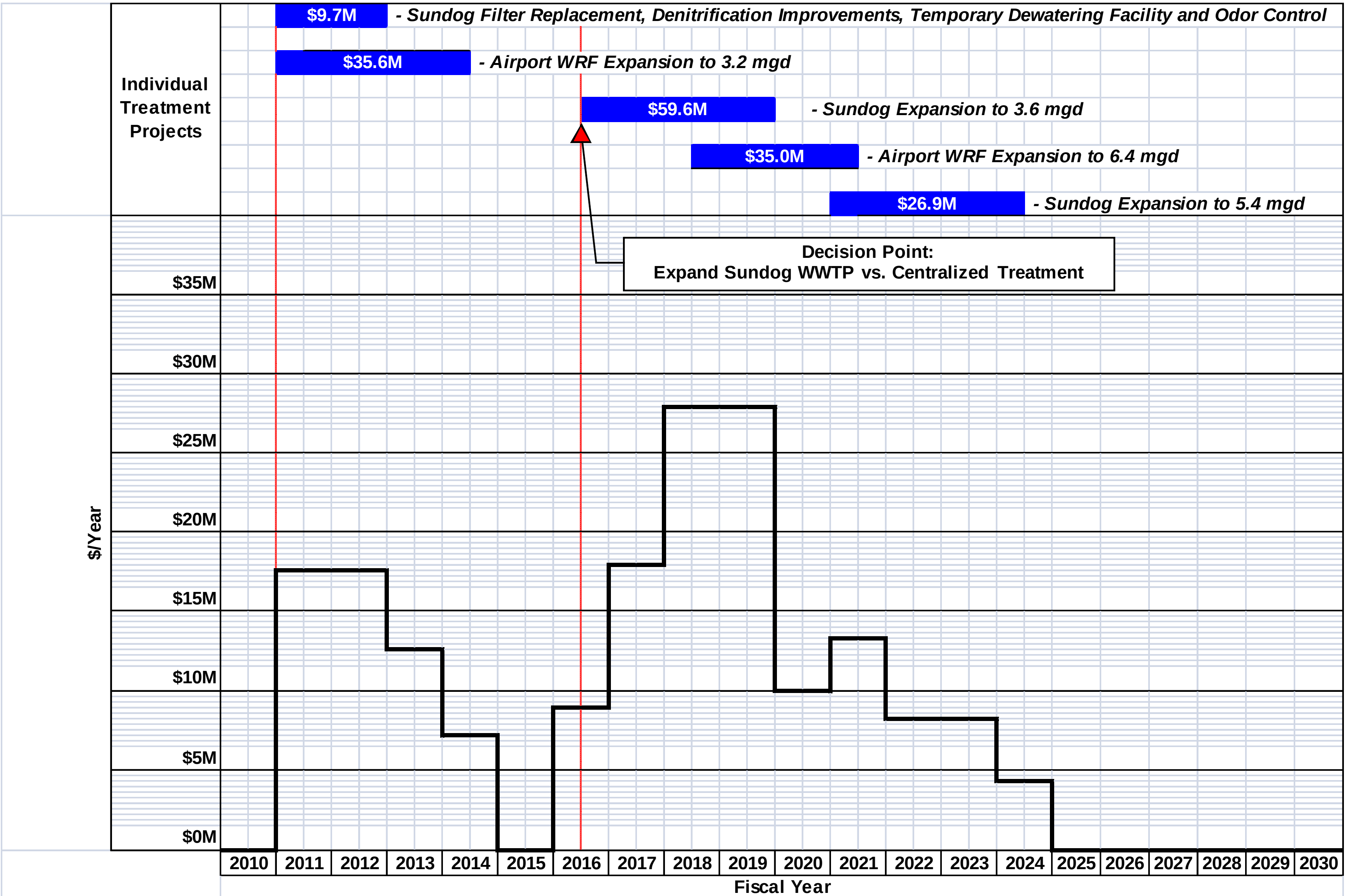


Figure 10.4 Decentralized Treatment Plants CIP

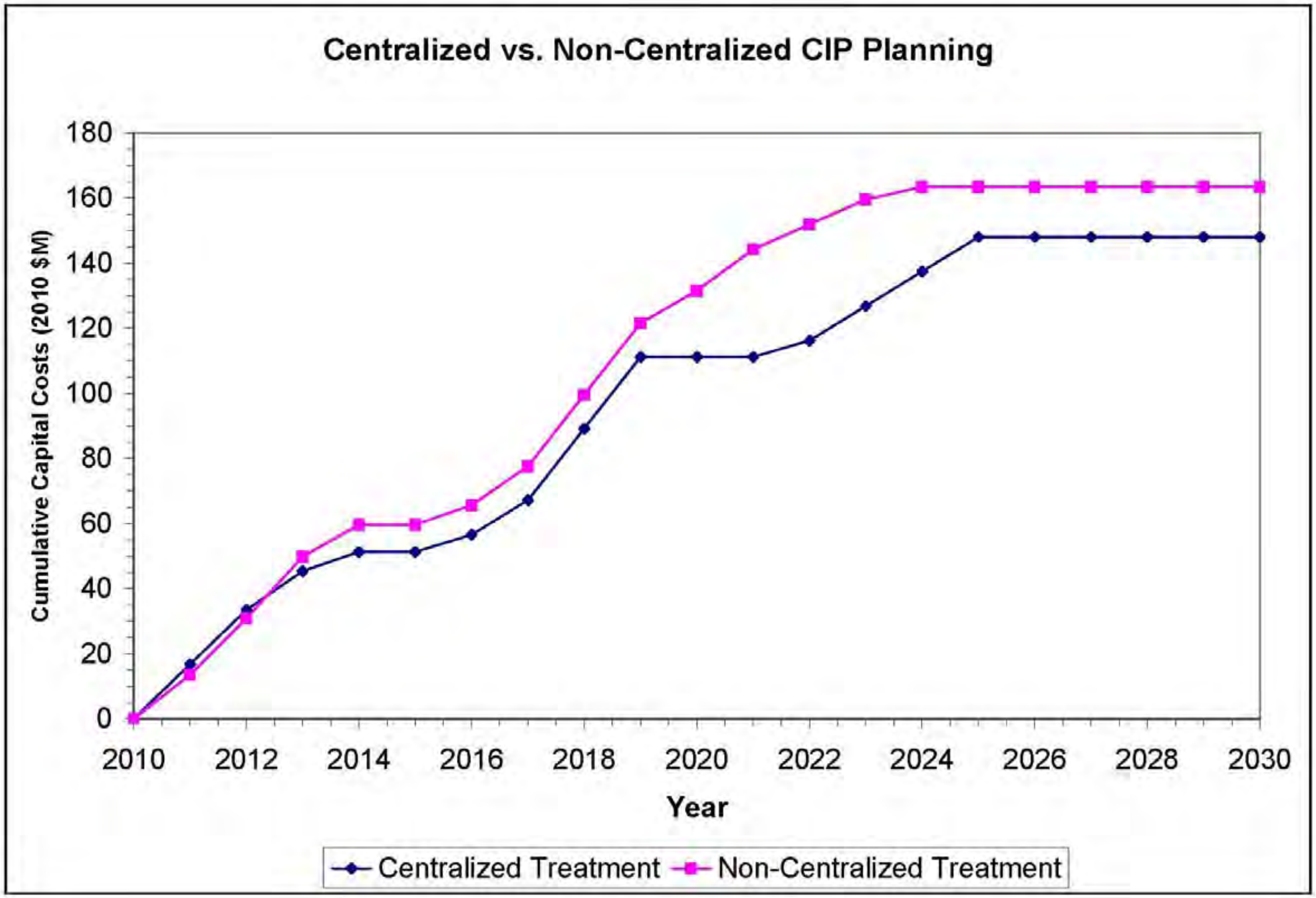


Figure 10.5 Cumulative Capital Cost Comparison

11.0 Conclusions

The economic comparison (20-year present worth), non-economic comparison and the comparison of phasing plans and corresponding capital improvement plans show very little difference between centralized treatment at the Airport WRF and decentralized treatment at the Airport WRF and Sundog WWTP. Furthermore, the centralized versus decentralized treatment decision point is not anticipated until 2016. Therefore,it is recommended the City maintain both options for as long as possible. As such the following recommendations and conclusions are provided.

- Plan the first phase of the Airport WRF improvements for 3.75 mgd of capacity which provides the flexibility for either approach.
- Recognize that an initial capacity of 3.75 mgd for the Airport WRF does not dictate the centralized treatment approach.
- Plan to make a decision on centralized treatment 2016, provided the actual flow increases are consistent with the projections herein.
- Recognize that if actual flow increase are less than projected the centralized treatment decision can be postponed beyond 2016.
- Consider collection system alternatives to divert flow away from the Sundog WWTP to the Airport WRF. This will in effect prolong the life expectancy of the Sundog WWTP and postpone the centralized treatment decision point.

Appendix A

Detailed Process Calculations

CAROLLO ENGINEERS, PC

W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Centralized Treatment Alternative Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE

Calc by CL Date Time 06/28/2010 4:41 PM Chk by/Date

Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
SUMMARY:								
FLOW RATES, mgd:								
- Raw WW Flow	3.8	5.3	7.5	12.8	7.5	12.1	15.0	24.2
- Flow to Primaries	3.9	5.6	7.9	13.4	7.8	12.8	15.7	25.6
- Influent Flow to Activated Sludge	3.9	5.6	7.9	13.5	7.8	12.7	15.6	25.4
INFLUENT WASTEWATER QUALITY, mg/L:								
- COD, mg/L	705	846	745	734	732	759	732	759
- BOD, mg/L	322	384	348	342	340	351	340	351
- TSS, mg/L	504	634	453	458	467	497	467	497
- NH3-N, mg/L	30	35	30	30	30	31	30	31
- TKN, mg/L	40	47	36	36	36	38	36	38
SECONDARY EFFLUENT QUALITY, mg/L:								
- BOD (est.), mg/L	2	3	2	3	3	4	3	4
- TSS (nominal), mg/L	10	10	10	10	10	10	10	10
- NH3-N, mg/L	0.10	0.59	0.10	0.39	0.05	0.49	0.05	0.48
- NO3-N, mg/L	4.6	4.7	4.5	3.4	5.8	4.8	5.8	4.8
- NO2-N, mg/L	0.02	0.14	0.02	0.11	0.01	0.14	0.01	0.14
- T.I.N., mg/L	4.7	5.5	4.6	3.9	5.9	5.5	5.8	5.4
- Organic N, mg/L	2.0	2.2	2.0	2.0	2.1	2.1	2.1	2.1
- T.N., mg/L	6.7	7.6	6.6	5.9	7.9	7.6	7.9	7.6
PRIMARY CLARIFIERS								
- # of Clarifiers	0	0	0	0	2	2	4	4
- # in Service	0	0	0	0	2	2	4	4
- Diameter, feet	-	-	-	-	80	80	80	80
- Surface Overflow Rate, gpd/sf	-	-	-	-	780	1,271	780	1,271
- Solids in Primary Sludge, lb/day	-	-	-	-	18,970	27,701	37,963	55,416
AERATION BASINS								
- # of Basins	2	2	4	4	2	2	4	4
- # in Service	2	2	4	4	2	2	4	4
- Total Anoxic Volume in Service, MG	2.24	2.24	4.48	4.48	2.24	2.24	4.48	4.48
- Total Aerobic Volume in Service, MG	5.04	5.04	10.07	10.07	5.04	5.04	10.07	10.07
- Total Aeration Basin volume, MG	7.27	7.27	14.55	14.55	7.27	7.27	14.55	14.55
- Hydraulic Deten. Time, hr	44.2	31.4	44.3	26.0	22.4	13.8	22.4	13.8
- Operating Last-Pass MLSS, mg/L	2,500	3,000	2,500	2,790	2,500	2,900	2,500	2,900
- Design Temperature, deg C	19.0	12.4	19.2	13.9	19.3	13.5	19.3	13.5
- Solids in WAS, ppd	6,656	13,100	12,399	24,612	5,179	14,238	10,308	28,429
- Aerobic SRT, days	16.2	9.9	16.7	9.4	19.2	8.5	19.3	8.6
- Total SRT, days	23.5	14.4	24.1	13.6	27.8	12.4	28.0	12.4
-- Recommended Min. Total SRT for Nitrification	5.3	12.6	5.1	10.1	5.1	10.7	5.1	10.7
- F/M, lb BOD Appl./lb MLSS-day	0.10	0.13	0.10	0.15	0.11	0.18	0.11	0.18
- Aer. BOD Loading, lb BOD/1000 cf-day	15	25	16	27	17	33	17	33
- ML Recirculation Ratio	4.3	4.2	3.8	4.3	3.8	4.3	3.9	4.3
- Process Air (est.), scfm	3,780	6,630	7,610	13,770	5,040	9,880	10,040	19,720
- Number of Blowers (incl. standby)	3	3	4	4	3	3	5	5
- Blower Capacity Required (each), scfm	2,500	4,300	3,300	6,000	3,300	6,400	3,300	6,400

CAROLLO ENGINEERS, PC	
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Calc by Date Time	Chk by/Date
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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 4 Design AADF	MLE Ph 4 Design MMADF Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
SECONDARY CLARIFIERS								
- # of Basins	2	2	3	3	3	3	6	6
- # in Service	1	2	2	3	2	3	5	6
- Diameter, feet	100	100	100	100	100	100	100	100
- Sec. Clarifier SOR, gpd/sf	491	343	491	555	492	530	393	530
- Sec. Clar. Solids Loading, lb/day-sf	14	13	14	20	14	20	11	20
- Clarifier Safety Factor (CSF)	2.6	3.0	2.6	2.0	2.6	2.0	3.2	2.0
-- CSF Target	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0
TERTIARY FILTERS								
- # of Units	3	3	6	6	6	6	10	10
- # in Service	2	2	5	5	5	5	9	9
- Surface area per filter, sf	646	646	646	646	646	646	646	646
- Filtration surface area in service, sf	1,291	1,291	3,228	3,228	3,228	3,228	5,810	5,810
- Loading rate at average day flow, gpm/sf	2.1	2.9	1.7	2.8	1.7	2.7	1.8	3.0
- Loading rate at peak flow, gpm/sf	4.1	4.1	3.3	3.3	3.3	3.3	3.7	3.7
- Backwash flow, % of influent	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

CAROLLO ENGINEERS, PC

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Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
DETAILED CALCULATIONS:								
RAW WASTEWATER (excluding Recycles)								
o Plant Flow Rate, mgd	3.8	5.3	7.5	12.8	7.5	12.1	15.0	24.2
o Flow Characteristic Ratios								
- Max Month/Annual Avg flow ratio	1	1.4	1	1.7	1	1.616	1	1.616
- Max Day/Annual Avg flow ratio	2.0	1.4	2.0	1.2	2.0	1.2	2.0	1.2
- Peak 4-hr Wet-W Flow/Annual Avg	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
o Wastewater Characteristics								
- BOD, mg/L, Annual Average	322	322	348	348	340	340	340	340
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective BOD, mg/L	322	384	348	342	340	351	340	351
- TSS, mg/L, Annual Average	504	504	453	453	467	467	467	467
-- Mass Load (lb/d) Peaking Factor	1	1.76	1	1.718	1	1.72	1	1.72
-- Effective TSS, mg/L	504	634	453	458	467	497	467	497
- Fpv, VSS fraction	0.862	0.862	0.87	0.87	0.87	0.87	0.87	0.87
-- Effective VSS, mg/L	434	546	394	398	406	432	406	432
- NH3-N, mg/L, Annual Average	29.5	29.5	30.2	30.5	30.2	30.2	30.2	30.2
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective NH3-N, mg/L	29.5	35.2	30.2	30.0	30.2	31.2	30.2	31.2
Organic-N, mg/L, Annual Average	10	10	6.1	6.1	6.1	6.1	6.1	6.1
-- Mass Load (lb/d) Peaking Factor	1	1.67	1	1.67	1	1.67	1	1.67
-- Effective Org-N, mg/L	10.0	11.9	6.1	6.0	6.1	6.3	6.1	6.3
- NO3-N + NO2-N, mg/L, Annual Average	0	0	0	0	0	0	0	0
- Alkalinity, mg/L, Annual Average	250	250	266	273	266	270	266	270
- Filterable ("soluble") BOD								
-- fraction, Fbf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
-- mg/L	64	77	70	68	68	70	68	70
- Fvu, Fraction VSS that is Unbiodeg	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
o Design Temperature, deg. C								
- Minimum (Winter)	12.4	12.4	13.9	13.9	13.5	13.5	13.5	13.5
- Maximum (Summer)	25.5	25.5	24.5	24.5	25	25	25	25
- Design	19.0	12.4	19.2	13.9	19.3	13.5	19.3	13.5
-- Total COD to BOD ratio	2.19	2.20	2.14	2.15	2.15	2.16	2.15	2.16
RECYCLE TO HEADWORKS/PRIM CLAR.S								
o Flow Rate, mgd								
- Backwash Flow	0.096	0.135	0.193	0.327	0.193	0.312	0.386	0.624
- Underflow/Filtrate/Return Flow	0.060	0.108	0.000	0.000	0.074	0.219	0.138	0.437
- Dewatering Centrate	0.031	0.060	0.167	0.353	0.079	0.126	0.157	0.252
- Total	0.187	0.303	0.359	0.680	0.346	0.657	0.681	1.313
o Wastewater Characteristics, mg/L								
- Total Recycle								
-- BOD	56	91	17	25	238	258	241	258
-- TSS	306	327	336	333	522	585	535	588
-- VSS	194	218	222	232	364	424	374	426
-- NH3-N	0	0	0	0	90	94	88	92
-- Organic-N	14	16	16	18	22	28	23	28
-- NO3-N + NO2-N	3	3	5	3	4	4	4	4
-- Alkalinity	86	68	142	155	372	532	586	902
-- Filterable ("soluble") BOD	0.5	0.6	0.7	0.9	160.1	135.3	162.2	135.2
-- Total soluble Organic N	1.1	1.1	1.5	1.5	2.3	2.2	2.3	2.2
-- Fpv, VSS fraction	0.63	0.66	0.66	0.70	0.70	0.72	0.70	0.73
- Fvu, Fraction VSS that is Unbiodeg	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700

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	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
PRIMARY TREATMENT	N.I.S.	N.I.S.	N.I.S.	N.I.S.	In Service	In Service	In Service	In Service
o Flow Rate, mgd								
- Raw Wastewater					7.5	12.1	15.0	24.2
- Recycle stream					0.35	0.66	0.68	1.31
- Total Influent					7.8	12.8	15.7	25.6
o Wastewater Characteristics, mg/L								
- BOD					335	347	336	347
- TSS					469	502	470	502
- VSS					404	432	405	432
- NH3-N					33	34	33	34
- Organic-N					7	7	7	7
- NO3-N + NO2-N					0	0	0	0
- Alkalinity					271	283	280	302
- Filterable ("soluble") BOD					72	74	72	74
- Fpv, VSS fraction					0.86	0.86	0.86	0.86
o Max biodegradable frac of VSS, est., mg/L					0.86	0.85	0.86	0.85
o Basin dimensions (inside)								
- Number of Basins	0	0	0	0	2	2	4	4
- Number of Units in Service	0	0	0	0	2	2	4	4
- Diameter, ft	80	80	80	80	80	80	80	80
- Side Water Depth, ft	12	12	12	12	12	12	12	12
- Surface Area per Basin, sf					5,027	5,027	5,027	5,027
- Surface Area in Service, sf	0	0	0	0	10,053	10,053	20,106	20,106
o Surface Overflow Rate, gpd/sf								
- At Design Flow					780	1,271	780	1,271
- At Diurnal Peak Flow					1,015	1,022	1,014	1,022
- At Peak WW Flow					1,561	1,573	1,560	1,573
o Detention Time, hr					2.8	1.7	2.8	1.7
o Chemically Enhanced Primary Treatment								
- CEPT applied? [Y=1; N=0]					0	0	0	0
o Removal Efficiency, %								
- BOD Removal, %					46.5	38.9	46.5	38.9
- TSS Removal, %					61.4	51.4	61.4	51.4
- Non-volatile SS %, Rpn					67.6	56.9	67.6	56.9
- Organic-N Removal, %					42.1	35.7	42.1	35.7
o Primary Sludge								
- BOD removed, lb/d					10,315	14,569	20,632	29,137
- Solids removed, lb/d								
-- Non-chemical primary solids					18,970	27,701	37,963	55,416
-- Chemical solids from CEPT					0	0	0	0
-- Total solids removed					18,970	27,701	37,963	55,416
- Concentration, %					3.0	3.0	3.0	3.0
- Flow Rate, mgd					0.076	0.111	0.152	0.221
- Flow Rate, gpm					53	77	105	154
- Organic N removed, lb/d					190	287	380	574
o Primary Effluent Flow, mgd					7.8	12.7	15.5	25.3
o Primary Effluent Characteristics, mg/L								
- BOD					180	212	180	212
- TSS					181	244	181	244
- VSS					160	214	160	214
- NH3-N					32.8	34.4	32.7	34.3
- Organic-N					3.95	4.77	3.95	4.77
- NO3-N + NO2-N					0.2	0.2	0.2	0.2
- Alkalinity					271	283	280	302
- Filterable ("soluble") BOD					72	74	72	74

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	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
ACTIVATED SLUDGE PROCESS								
o Flow Rate, mgd								
- Total Main Influent to Activated Sludge	3.95	5.56	7.88	13.45	7.79	12.69	15.57	25.38
o Influent Characteristics, mg/L								
- Total BOD	309	367	332	325	179	211	179	211
- TSS	493	616	446	451	181	243	181	243
- VSS	422	527	385	389	160	213	160	213
- NH3-N	28	33	29	28	33	34	33	34
- Organic-N	10	12	7	7	4	5	4	5
- NO3-N + NO2-N	0	0	0	0	0	0	0	0
- Alkalinity	242	240	260	267	270	283	279	302
- Filterable ("soluble") BOD	61	73	66	65	72	73	72	73
- Fpv, VSS fraction	0.86	0.86	0.86	0.86	0.88	0.88	0.88	0.88
- AB Influent D.O. Concentration, mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o Basin dimensions								
- Main Basins - Oxidation Ditch								
-- No. of Basins	2	2	4	4	2	2	4	4
-- Number of Units in Service	2	2	4	4	2	2	4	4
-- Length, ft (inside)	260	260	260	260	260	260	260	260
-- Width, ft (inside)	110	110	110	110	110	110	110	110
-- Side Water Depth, ft	17	17	17	17	17	17	17	17
.. Recomm inside Wall height, incl. Freeboard, ft	20	20	20	20	20	20	20	20
-- Liquid Volume per Basin, mil gal	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64
- Supplemental Basins or Sections								
-- Identification								
-- No. of Basins	0	0	0	0	0	0	0	0
-- Number of Units in Service	0	0	0	0	0	0	0	0
-- Length, ft (inside)	0	0	0	0	0	0	0	0
-- Width, ft (inside)	0	0	0	0	0	0	0	0
-- Side Water Depth, ft	0	0	0	0	0	0	0	0
-- Volume per Basin, mil gal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Total Volume of Basins, mil gal								
- Total Basin volume in service	7.27	7.27	14.55	14.55	7.27	7.27	14.55	14.55
-- Reduction for MBR cassettes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Biological Reaction Volume	7.27	7.27	14.55	14.55	7.27	7.27	14.55	14.55
o Aerated Zone BOD Loading, lb/1,000 cf-day	15.0	25.1	16.2	27.0	17.1	32.7	17.1	32.7
o Hydraulic Detention Time, hr	44.22	31.37	44.30	25.95	22.40	13.76	22.42	13.76
o Selected Operating L-P MLSS, mg/L	2,500	3,000	2,500	2,794	2,500	2,901	2,500	2,901
PROCESS LAYOUT								
o Zone Sizes (Fraction of Total Volume)								
- Zone 1	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
- Zone 2	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
- Zone 3	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
- Zone 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- Zone 5	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
- Zone 6	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
- Zone 7 (by difference)	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
-- Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
o DO in each Zone (Unaerated, Set = 0), mg/L								
- Zone 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Zone 4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Zone 7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

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	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
o Aerated/Unaerated Fractions								
- Total Unaerated Volume Fraction	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
-- Total Unaerated Volume, mil gal	2.24	2.24	4.48	4.48	2.24	2.24	4.48	4.48
- Total Aerated Volume Fraction	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
-- Total Aerated Volume, mil gal	5.04	5.04	10.07	10.07	5.04	5.04	10.07	10.07
- Total Aerated Mass Fraction	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
o Plant Influent Flow Routing								
- Fraction to Zone 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
- Fraction to Zone 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- Remainder to Zone 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Sludge Wasting Method								
- Wasting from RAS (1) or ML (0)	1	1	1	1	1	1	1	1
-- If ML, Waste taken from Zone # (1, 2, - - 7)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)	(RAS)
o Mixed-Liquor Recirculation (MLR#1) Routing								
- MLR Taken from Zone (0, 1, 2, - - 7); 0=NA	7	7	7	7	7	7	7	7
- MLR Returned to Zone (0, 1, 2, - - 7); 0=NA	1	1	1	1	1	1	1	1
- MLR Flow, mgd	16.88	23.63	30.00	57.38	30.00	54.54	60.00	109.08
- MLR Flow per train, mgd	5,859	8,203	5,208	9,961	10,417	18,937	10,417	18,937
- MLR Ratio	4.27	4.25	3.81	4.27	3.85	4.30	3.85	4.30
LOADING CRITERIA								
o BOD Applied, lb/d								
- BOD in Influent	10,158	17,047	21,819	36,493	11,637	22,359	23,270	44,715
- BOD in External Stream	0	0	0	0	0	0	0	0
- (-) WAS Recycled	64	171	51	138	96	360	191	719
- Net BOD Load	10,093	16,876	21,768	36,354	11,541	21,998	23,079	43,996
o MLSS under aeration, lb	105,441	126,563	210,836	235,440	105,270	122,103	210,539	244,209
- F/M, lb BOD Appl./lb MLSS-day	0.10	0.13	0.10	0.15	0.11	0.18	0.11	0.18
o Organic Loading, Based on Aerated Zone								
- Aerated Volume in Service, 1,000 cf	673	673	1,346	1,346	673	673	1,346	1,346
- Aer. BOD Loading, lb BOD/1000 cf-day	15.0	25.1	16.2	27.0	17.1	32.7	17.1	32.7
o Unaerated Zone								
- Actual HRT (Throughflow), hr	2.41	1.69	2.63	1.39	1.32	0.73	1.32	0.73
- Mixing Power, total								
-- Total BHP, all Unaerated Zones	78.3	78.3	156.7	156.7	78.3	78.3	156.7	156.7
-- Mixing, hp/mil gal	35	35	35	35	35	35	35	35
WAS SOLIDS PRODUCTION								
o Solids Production, TSS, lb/d								
- TSS Entering in Feed, lb/d	16,945	29,813	30,428	52,435	13,455	28,647	26,910	57,303
- TSS Entering in External Input, lb/d	0	0	0	0	0	0	0	0
- VSS Change in A.B. Zones	-10,166	-16,695	-17,791	-27,644	-7,865	-14,009	-15,777	-28,070
- ISS Change in A.B. Zones	198	432	405	912	233	640	462	1,277
- ISS due to Bio-P (Est.), lb/d	0	0	0	0	0	0	0	0
- Unbiodeg VSS due to Bio-P (Est.), lb/d	0	0	0	0	0	0	0	0
- Total Solids Production, lb/d	6,978	13,550	13,042	25,703	5,823	15,278	11,595	30,511

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SUBJECT: PROCESS ANALYSIS AND MASS BALANCE								
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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 4 Design AADF	MLE Ph 4 Design MMADF Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
SOLIDS RETENTION TIME, SRT								
o Total Solids Wasted, lb/d	6,978	13,550	13,042	25,703	5,823	15,278	11,595	30,511
- Recycled WAS Solids, lb/d	476	826	386	655	349	995	696	1,988
- Net lb Solids Yield/day	6,502	12,723	12,657	25,048	5,473	14,283	10,899	28,522
o Total BOD Load, lb/d	10,093	16,876	21,768	36,354	11,541	21,998	23,079	43,996
- Recycled BOD, lb/d	64	171	51	138	96	360	191	719
- Net BOD Load, lb/d	10,029	16,704	21,718	36,216	11,446	21,638	22,888	43,277
o Solids Production								
- lb Dry SS/lb BOD Applied	0.648	0.762	0.583	0.692	0.478	0.660	0.476	0.659
o Total Mass TSS in System, lb	152,915	183,525	305,602	340,972	152,361	176,666	304,724	353,335
- Total SRT (Rs), days	23.52	14.42	24.15	13.61	27.84	12.37	27.96	12.39
o Total Mass TSS in Aerated Zones, lb	105,441	126,563	210,836	235,440	105,270	122,103	210,539	244,209
- Nominal Aerated Mass Fraction	0.690	0.690	0.690	0.690	0.691	0.691	0.691	0.691
- Nominal Aerobic SRT, days	16.22	9.95	16.66	9.40	19.23	8.55	19.32	8.56
o Min. Aer. SRT recommended for nitrification, days	3.6	8.7	3.5	7.0	3.5	7.4	3.5	7.4
- Washout SRT(total)								
-- Rwashout = 1/(Ua*DOsw - ba)	2.69	5.98	2.62	4.92	2.59	5.16	2.59	5.16
- Recommended Operating SRT								
-- Max slope criterion, as dNH3/dSRT, mg/L-d	0.38	0.16	0.39	0.20	0.39	0.19	0.39	0.19
-- Recomm. Min. Operating SRT(total)	5.3	12.6	5.1	10.1	5.1	10.7	5.1	10.7
-- Recomm. Min. Op. SRT(Nominal aerobic)	3.6	8.7	3.5	7.0	3.5	7.4	3.5	7.4
-- Nitrification Safety Factor	1.96	2.10	1.96	2.06	1.96	2.07	1.96	2.07
AERATION REQUIREMENTS								
o Oxygen Required, lb/d								
- Net Oxygen Demand in Zone 1	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 2	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 3	12	12	0	0	0	0	0	0
- Net Oxygen Demand in Zone 4	0	0	0	0	0	0	0	0
- Net Oxygen Demand in Zone 5	5,881	7,737	11,868	16,010	9,341	12,232	18,623	24,439
- Net Oxygen Demand in Zone 6	3,713	6,366	7,469	13,026	5,116	9,915	10,168	19,792
- Net Oxygen Demand in Zone 7	2,780	5,190	5,653	10,632	3,595	8,045	7,138	16,041
- (-) Oxygen provided by MBR Scouring	0	0	0	0	0	0	0	0
- Total Oxygen required lb/d	12,385	19,305	24,991	39,669	18,053	30,192	35,929	60,272
o Diffuser Analysis								
Note:								
All values of air and blower requirements given below are preliminary estimates, to be refined during detailed design								
o Oxygen Transfer Efficiency	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]	[Sanitaire]
- Diffuser Type	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"	Membrn Disk 9"
- Aeration Basin D.O. (Avg), mg/L	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Design Water Temperature, C	25.5	25.5	24.5	24.5	25	25	25	25
- Diffuser submergence, ft	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
- Air loading, scfm/unit	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr	0.95 scfm/dfr	1.59 scfm/dfr
- Floor Coverage	24.3 At/Ad	23.1 At/Ad	24.1 At/Ad	22.3 At/Ad	18.2 At/Ad	15.5 At/Ad	18.3 At/Ad	15.5 At/Ad

CAROLLO ENGINEERS, PC	
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Calc by / Date Time / Chk by/Date	
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Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
- Clean Water SOTE	27.3	26.3	27.4	26.7	29.8	29.5	29.8	29.5
- Site Conditions Adjustment Factor								
F = Actual / Standard OTE								
-- Alpha factor, including fouling	0.75	0.69	0.75	0.67	0.75	0.65	0.75	0.65
-- Theta factor	1.024	1.024	1.024	1.024	1.024	1.024	1.024	1.024
-- Temp. correction, Tau	0.90	0.90	0.92	0.92	0.91	0.91	0.91	0.91
-- Elevation above MSL, ft	4,910	4,910	4,910	4,910	4,910	4,910	4,910	4,910
-- ..Pressure correction, Omega	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
-- Beta factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
-- Equilibrium C*20	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66
..Depth Adjustment Factor	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
- F = Alpha x [Theta ^(T-20)]	0.47	0.44	0.48	0.43	0.47	0.41	0.47	0.41
x (Tau Beta Omega C*20 - C)/C*20								
- Oxygen Transfer Efficiency	12.96	11.53	13.00	11.40	14.18	12.10	14.16	12.10
OTE = F x SOTE	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Preliminary Estimate								
o SOTR Required								
- Average Day @ Design flow								
-- Actual Ox Tr Requd, AOTR, lb/d	12,385	19,305	24,991	39,669	18,053	30,192	35,929	60,272
-- Site Conditions Adjustment, F	0.47	0.44	0.48	0.43	0.47	0.41	0.47	0.41
-- Standard Ox Tr Rate, SOTR, lb/d	26,085	44,046	52,587	92,820	38,006	73,669	75,641	146,969
SOTR = AOTR / F								
o Air Supply Required								
- Average Day @ Design flow								
-- Ox Transfer Rate, AOTR, lb/d	12,385	19,305	24,991	39,669	18,053	30,192	35,929	60,272
-- Oxygen Supplied, lb/min	66.3	116.2	133.5	241.6	88.4	173.3	176.2	346.0
-- cf Air/lb Oxygen	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0
[23.3 lb O2/100 lb Air]								
[0.0753 lb Air/scf]								
-- Process Air, scfm	3,780	6,630	7,610	13,770	5,040	9,880	10,040	19,720
..scfm per lb/d Oxygen	0.305	0.343	0.305	0.347	0.279	0.327	0.279	0.327
..scf/lb BOD Applied	539	566	503	545	629	647	626	645
-- Other Uses, e.g. Channel Air	0	0	0	0	0	0	0	0
-- Total Blower Air, scfm	3,780	6,630	7,610	13,770	5,040	9,880	10,040	19,720
- Peak Day @ Design Flow								
-- Peaking factor	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
-- Process Air, scfm	4,900	8,600	9,900	17,900	6,600	12,800	13,100	25,600
-- Total Blower Air, scfm	4,900	8,600	9,900	17,900	6,600	12,800	13,100	25,600
o Diffusers								
- Expressed as active sq ft or # diffusers	dfr	dfr	dfr	dfr	dfr	dfr	dfr	dfr
- Recommended								
-- Air Loading, scfm/(sf or dfr)	0.95	1.59	0.95	1.59	0.95	1.59	0.95	1.59
-- Number recommended per Basin	1,990	2,088	2,002	2,170	2,653	3,114	2,642	3,107
- Actual Installed, per basin								
-- Main Basin	1,990	2,088	2,002	2,170	2,653	3,114	2,642	3,107
-- Additional Basin	0	0	0	0	0	0	0	0
- Total Installed, sf or dfr	3,981	4,176	8,008	8,680	5,306	6,227	10,570	12,429
- Air Loading, scfm/sf or dfr								
-- Daily Average	0.95	1.59	0.95	1.59	0.95	1.59	0.95	1.59
- Floor Coverage								
-- Total Basin Floor Area in Service, sf	57,200	57,200	114,400	114,400	57,200	57,200	114,400	114,400
-- Total Aerated Floor Area in service	39,600	39,600	79,200	79,200	39,600	39,600	79,200	79,200
-- Coverage	24.3	23.1	24.1	22.3	18.2	15.5	18.3	15.5
.. Expressed as	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad	At/Ad
- Active sf/diffuser, or 1	1	1	1	1	1	1	1	1
- Number of diffuser units	3,981	4,176	8,008	8,680	5,306	6,227	10,570	12,429

Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
o Blower Discharge pressure								
- Head, ft water								
-- Submergence	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
-- Freeboard above normal op level	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-- Diffuser head loss	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
-- Pipe & Valve friction	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
-- Total Head, ft	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
- Discharge pressure, psig	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
o Delivered Horsepower								
- Max Operating Air Temp, C	30.5	30.5	29.5	29.5	30	30	30	30
- Barometric Pressure, psia	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3
- Blower Suction Pressure, psia	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
- Daily Average Total Air, scfm	3,780	6,630	7,610	13,770	5,040	9,880	10,040	19,720
- Avg Delivered Horsepower, hp	150	263	300	544	199	391	397	780
- Peak Day Delivered hp	194	341	391	707	261	506	518	1,013
o Wire power required								
- Energy Efficiency, %	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0
- Wire power required, hp								
-- Daily Average	250	430	490	890	330	640	650	1,280
-- Firm Installed	320	560	640	1,160	430	830	850	1,660
o Blowers Required								
- Number of Blowers	3	3	4	4	3	3	5	5
- Capacity, each, scfm	2,500	4,300	3,300	6,000	3,300	6,400	3,300	6,400
- Firm Capacity, scfm	5,000	8,600	9,900	18,000	6,600	12,800	13,200	25,600
SECONDARY SEDIMENTATION BASINS								
o Flow Rates, mgd								
- AS Influent, Q	3.95	5.56	7.88	13.45	7.79	12.69	15.57	25.38
- Net Sed. Basin Inflow (excl. RAS), Qci	3.95	5.56	7.88	13.45	7.79	12.69	15.57	25.38
- Return Sludge Flow, Qr	1.50	2.51	2.99	6.56	3.00	6.58	5.54	13.17
(not including waste sludge flow)								
- Total Sed Basin Inflow	5.44	8.07	10.87	20.01	10.79	19.27	21.11	38.54
- Total Sed. Basin Underflow	1.59	2.68	3.16	6.93	3.07	6.79	5.67	13.58
- Net Sec. Effluent, Qe	3.85	5.39	7.71	13.09	7.72	12.48	15.44	24.96
o Basin dimensions								
- Group 1								
-- No. of Basins	2	2	3	3	3	3	6	6
-- Number of Units in Service	1	2	2	3	2	3	5	6
-- Diameter, ft (inside)	100	100	100	100	100	100	100	100
-- Side Water Depth, ft	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
-- Surface Area per Basin, sf	7,854	7,854	7,854	7,854	7,854	7,854	7,854	7,854
-- Volume per Basin, cf	117,810	117,810	117,810	117,810	117,810	117,810	117,810	117,810
o Surface Overflow Rate								
- Group 1								
-- Surface Area in service, sf	7,854	15,708	15,708	23,562	15,708	23,562	39,270	47,124
-- Surface Overflow Rate, gpd/sf	491	343	491	555	492	530	393	530
o Solids Loading Rate, lb/day-sf								
- Group 1	14	13	14	20	14	20	11	20
o Volume in service, mil gal								
- Group 1	0.88	1.76	1.76	2.64	1.76	2.64	4.41	5.29
o Hydraulic Detention Time, hr (based on Q)								
- Group 1	5.4	7.6	5.4	4.7	5.4	5.0	6.8	5.0
o Weir Loading								
- Group 1								
-- Actual weir length per unit, ft	305	305	305	305	305	305	305	305
-- Weir loading, gpd/ft	12,648	8,843	12,647	14,314	12,669	13,652	10,134	13,652

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Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 4 Design AADF	MLE Ph 4 Design MMADF Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
o Sludge Settling Characteristics								
$ISV = V_0 \exp(-MLSS/X_M)$, ft/h								
- Design Settling Constants								
-- V_0, ft/hr	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
-- X_M, mg/L	2,260	2,260	2,260	2,260	2,260	2,260	2,260	2,260
o Target Settling Values								
- Effluent rise rate (SOR), ft/hr								
-- Average	2.73	1.91	2.73	3.09	2.74	2.95	2.19	2.95
- Clarifier Safety Factor, CSF	2.30	2.00	2.30	2.00	2.30	2.00	2.30	2.00
- Max. Initial Settling Velocity, ISV, ft/hr	6.3	3.8	6.3	6.2	6.3	5.9	5.0	5.9
- Preferred Max. Last-Pass MLSS, mg/L	2,758	3,882	2,758	2,794	2,754	2,901	3,258	2,901
o Selected Settling Values								
- Operating L-P MLSS conc, mg/L	2,500	3,000	2,500	2,794	2,500	2,901	2,500	2,901
- Operating ISV, ft/h	7.05	5.65	7.05	6.19	7.05	5.90	7.05	5.90
- Operating CSF								
-- Average	2.58	2.95	2.58	2.00	2.57	2.00	3.22	2.00
SLUDGE RETURN AND WASTAGE								
o Wasting Method (see Process Layout)								
- Waste Flow from RAS, Qw	0.093	0.174	0.174	0.367	0.071	0.208	0.133	0.415
- Waste Flow from MLSS, Zone 7, Qmw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o Return Sludge								
- Qr/Q, fraction (based on Qr to Aer Basin)	0.38	0.45	0.38	0.49	0.38	0.52	0.36	0.52
-- [Clarifier Underflow fraction]	0.40	0.48	0.40	0.52	0.39	0.54	0.36	0.54
- RAS flow to Aer Basin, Qr, mgd Average	1.50	2.51	2.99	6.56	3.00	6.58	5.54	13.17
- RAS concentration, mg/L	8,539	9,009	8,564	8,051	8,764	8,214	9,280	8,214
o Sludge Wastage								
- Total Solids Wasted, lb/d	6,978	13,550	13,042	25,703	5,823	15,278	11,595	30,511
- Adjustment for ESS:								
-- Solids in Effluent, lb/d	321	449	643	1,091	644	1,041	1,288	2,082
-- Solids in WAS, lb/d	6,656	13,100	12,399	24,612	5,179	14,238	10,308	28,429
- Concentration, mg/L	8,539	9,009	8,564	8,051	8,764	8,214	9,280	8,214
- Organic N, lb/d	275	599	532	1,197	278	814	552	1,623
- Flow Rate, mgd Average	0.093	0.174	0.174	0.367	0.071	0.208	0.133	0.415
- Flow Rate, gpd Average	93,469	174,362	173,597	366,532	70,851	207,839	133,179	414,986
o WAS Characteristics, mg/L								
- Wasting from -	RAS	RAS	RAS	RAS	RAS	RAS	RAS	RAS
- BOD	1,185	1,843	1,238	1,799	1,556	2,297	1,637	2,293
- TSS	8,539	9,009	8,564	8,051	8,764	8,214	9,280	8,214
- VSS	5,420	5,988	5,657	5,605	6,360	6,164	6,727	6,163
- NH3-N	0.1	0.6	0.1	0.4	0.0	0.5	0.0	0.5
- Organic-N	353.2	411.8	367.4	391.6	470.8	469.5	496.6	469.0
- NO3-N + NO2-N	4.6	4.7	4.5	3.4	5.8	4.8	5.8	4.8
- Alkalinity	126	106	142	155	133	145	143	164
- Filterable ("soluble") BOD	0.7	0.9	0.7	0.9	0.8	1.0	0.8	1.0
- Total soluble Organic N	1.6	1.7	1.5	1.5	1.5	1.6	1.5	1.6
o Recommended Installed Capacity								
- Min. Underflow requ'd at peak flow, $Q_{Rmin,p}$	2.82	3.72	5.63	10.97	5.65	11.14	9.85	22.28
- Thickening Safety Factor	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
- Recomm. Underflow Capacity, mgd	3.10	4.09	6.19	12.07	6.21	12.25	10.84	24.51
- Installed Return Sludge Pumps, mgd	3.00	3.92	6.02	11.70	6.14	12.05	10.70	24.09
-- gpm	2,080	2,720	4,180	8,120	4,260	8,360	7,430	16,720
- WAS Pumps								
-- Wasting operation, hr/day	24	24	24	24	24	24	24	24
-- Pump Capacity (2 x Qwas), gpm	130	250	250	510	100	290	190	580
-- WAS Solids Peak Handling Capacity, lb/hr	560	1,100	1,040	2,060	440	1,190	860	2,370

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	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
SECONDARY EFFLUENT								
o Flow Rate								
- Net Secondary Effluent, mgd	3.85	5.39	7.71	13.09	7.72	12.48	15.44	24.96
o Secondary Effluent Quality								
- BOD, mg/L	2	3	2	3	3	4	3	4
- TSS (nominal), mg/L	10	10	10	10	10	10	10	10
- VSS, mg/L	6.3	6.6	6.6	7.0	7.3	7.5	7.2	7.5
- NH3-N, mg/L	0.1	0.6	0.1	0.4	0.0	0.5	0.0	0.5
- Total Organic N, mg/L	2.0	2.2	2.0	2.0	2.1	2.1	2.1	2.1
- NO3-N, mg/L	4.6	4.7	4.5	3.4	5.8	4.8	5.8	4.8
- NO2-N, mg/L	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
- Alkalinity, mg/L	126	106	142	155	133	145	143	164
- Soluble Organic N, mg/L	1.6	1.7	1.5	1.5	1.5	1.6	1.5	1.6
- T.I.N., mg/L	4.7	5.5	4.6	3.9	5.9	5.5	5.8	5.4
- Total N, mg/L	6.7	7.6	6.6	5.9	7.9	7.6	7.9	7.6
TERTIARY FILTRATION	In Service	In Service	In Service	In Service	In Service	In Service	In Service	In Service
o Tertiary Filtration in Service? (Y=1, N=0)	1	1	1	1	1	1	1	1
o Influent								
- Flow, mgd								
-- Total	3.9	5.4	7.7	13.1	7.7	12.5	15.4	25.0
- BOD, total, mg/L	2.0	3.0	2.0	3.0	3.0	4.0	3.0	4.0
- SS, total, mg/L	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
o Filter Area								
- Surface Area per Filter, sf	646	646	646	646	646	646	646	646
- Backwash - Continuous (0) or Intermittent (1)?	0	0	0	0	0	0	0	0
- Standby Units Provided	1	1	1	1	1	1	1	1
- Number of Filters								
-- Total	3	3	6	6	6	6	10	10
- Number of Units in Service	2	2	5	5	5	5	9	9
o Filter Loading								
- Surface Area in Service, sf	1,291	1,291	3,228	3,228	3,228	3,228	5,810	5,810
- Liquid Loading Rate, gpm/sf								
-- At Daily Average Flow, gpm/sf	2.1	2.9	1.7	2.8	1.7	2.7	1.8	3.0
-- At Peak Flow, gpm/sf	4.1	4.1	3.3	3.3	3.3	3.3	3.7	3.7
o Removal								
- SS Removal, %	60	60	60	60	60	60	60	60
- SS removed, lb/d	193	270	386	655	386	625	773	1,249
- BOD removed, lb/d	24	56	50	136	86	189	172	379
o Backwash Flow								
- Percent of Flow, %	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
- Backwash Flow, mgd	0.10	0.13	0.19	0.33	0.19	0.31	0.39	0.62
o Backwash Characteristics, mg/L								
- BOD	31	51	32	51	54	74	54	74
- TSS	240	240	240	240	240	240	240	240
- VSS	152	160	159	167	174	180	174	180
- NH3-N	0.1	0.6	0.1	0.4	0.0	0.5	0.0	0.5
- Organic-N	11	13	12	13	14	15	14	15
- NO3-N + NO2-N	4.6	4.9	4.5	3.5	5.8	5.0	5.8	5.0
- Alkalinity	126	106	142	155	133	145	143	164
o Net Flow to Disinfection, mgd								
- To Disinfection	3.76	5.25	7.52	12.76	7.53	12.17	15.05	24.34

CAROLLO ENGINEERS, PC

W.O./CLIENT:	8286A.00 / City of Prescott
PROJECT:	Airport WRF - Centralized Treatment Alternative Evaluation
SUBJECT:	PROCESS ANALYSIS AND MASS BALANCE

Calc by CL Date Time 06/28/2010 4:41 PM Chk by/Date

Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
o Tertiary Effluent Quality, mg/L								
- BOD	1.2	1.7	1.2	1.8	1.7	2.2	1.7	2.2
- SS	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
- VSS, mg/L	2.5	2.7	2.6	2.8	2.9	3.0	2.9	3.0
- NH3-N, mg/L	0.1	0.6	0.1	0.4	0.0	0.5	0.0	0.5
- Total Organic N, mg/L	1.7	1.9	1.7	1.7	1.8	1.8	1.7	1.8
- NO3-N + NO2-N, mg/L	4.6	4.9	4.5	3.5	5.8	5.0	5.8	5.0
- Alkalinity, mg/L	126	106	142	155	133	145	143	164
- Filterable ("soluble") BOD	0.7	0.9	0.7	0.9	0.8	1.0	0.8	1.0
- Soluble Organic N, mg/L	1.6	1.7	1.5	1.5	1.5	1.6	1.5	1.6
- T.I.N., mg/L	4.7	5.5	4.6	3.9	5.9	5.5	5.8	5.4
- Total N, mg/L	6.5	7.4	6.3	5.6	7.6	7.3	7.6	7.2
RESIDUALS MANAGEMENT								
SOLIDS GENERATED								
o Total Primary Sludge								
- Flow, mgd	0.000	0.000	0.000	0.000	0.076	0.111	0.152	0.221
- Solids, lb/d	0	0	0	0	18,970	27,701	37,963	55,416
- Concentration, %	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
- VSS, %	100	100	100	100	85	85	85	85
- Volatile solids, lb/d	0	0	0	0	16,077	23,451	32,175	46,916
- Organic N, lb/d	0	0	0	0	190	287	380	574
o Total Waste Activated Sludge								
- Flow, mgd	0.093	0.174	0.174	0.367	0.071	0.208	0.133	0.415
- Solids, lb/d	6,656	13,100	12,399	24,612	5,179	14,238	10,308	28,429
- Concentration, %	0.85	0.90	0.86	0.81	0.88	0.82	0.93	0.82
- VSS, %	63	66	66	70	73	75	72	75
- Volatile solids, lb/d	4,225	8,707	8,190	17,133	3,758	10,685	7,472	21,329
- Organic N, lb/d	275	599	532	1,197	278	814	552	1,623
SLUDGE ROUTING								
o Primary Sludge								
- (a) Thickening	None	None	None	None	None	None	None	None
- (b) Then routed to - -	N.A.	N.A.	N.A.	N.A.	Anaer Digs	Anaer Digs	Anaer Digs	Anaer Digs
o Waste Activated Sludge								
- (a) Thickening	Grav Thkr	Grav Thkr	None	None	GBT	GBT	GBT	GBT
- (b) Then routed to - -	Dewatering	Dewatering	Dewatering	Dewatering	Anaer Digs	Anaer Digs	Anaer Digs	Anaer Digs
GRAVITY THICKENERS	In Service	In Service	NA	NA	NA	NA	NA	NA
o Service	WAS	WAS	NA	NA	NA	NA	NA	NA
o Sludge Feed								
- Flow, mgd	0.093	0.174						
- Solids, lb/d	6,656	13,100						
- Concentration, %	0.9	0.9						
o Basin dimensions								
- No. of Basins	1	1						
- Number of Units in Service	1	1						
- Diameter, ft (inside)	50	50						
- Total Effective Area, sf	1,886	1,886						
o Thickener Loading								
- Solids Loading, lb/hr-sf	0.15	0.29						
– Hydraulic Loading, gpd/sf	50	92						
o Thickened Sludge								
- Solids Capture, %	85	85						
- Thk Sl Solids, lb/d	5,658	11,135						
- Thk Sl Solids, %	2.0	2.0						
- Thk Sl Flow, mgd	0.034	0.067						

CAROLLO ENGINEERS, PC	
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Calc by CL	Date Time 06/28/2010 4:41 PM Chk by/Date

Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
GRAVITY BELT/ROTARY DRUM THICKENING OF WAS	NA	NA	NA	NA	GBT	GBT	GBT	GBT
o Service	NA	NA	NA	NA	WAS	WAS	WAS	WAS
o Sludge Feed								
- Flow rate, mgd					0.071	0.208	0.133	0.415
-- Operating hours per Week					42	42	42	42
-- Recomm Installed Capacity, gpm					393	1,154	739	2,304
- Total Solids, lb/d					5,179	14,238	10,308	28,429
-- Recomm Installed Capacity, lb/hr					131	385	246	768
o Number of Units					2	2	3	3
- Number of Units in Service					1	1	2	2
- Feed Rate, Rotary Drum Thickener:					NA	NA	NA	NA
-- gpm per unit					400	400	400	400
- Feed Rate, Gravity Belt					GBT	GBT	GBT	GBT
-- Belt width, m					2	2	2	2
-- Feed Rate, gpm per meter					250	250	250	250
-- gpm per unit					500	500	500	500
- Operating cycle								
-- days/week					5	6	5	6
-- hours/day (calc)					3.3	8.1	3.1	8.1
o Thickened Solids								
- Solids Capture, %					90	90	90	90
- Thickened Solids, lb/d					4,661	12,814	9,277	25,586
- Concentration, %					5.0	5.0	5.0	5.0
- Flow Rate, mgd Average					0.011	0.031	0.022	0.061
- Volatile Solids, lb/d					3,382	9,617	6,725	19,196
- Organic N, lb/d					250	732	496	1,461
- Recomm Installed Pump Capacity, gpm					6	16	10	31
o Combined Filtrate & Wash Water								
- Unrecovered Solids, lb/d					518	1,424	1,031	2,843
- Flow								
-- Filtrate, mgd					0.060	0.177	0.111	0.354
-- Wash water, mgd/mgd feed					0.2	0.2	0.2	0.2
. . Wash Water flow, mgd (daily average)					0.014	0.042	0.027	0.083
-- Total Flow, mgd					0.074	0.219	0.138	0.437
- Characteristics, mg/L								
-- BOD					149	218	158	218
-- TSS					841	781	898	781
-- VSS					610	586	651	586
-- NH3-N					0.0	0.5	0.0	0.5
-- Organic-N					47	46	50	46
-- NO3-N + NO2-N					5.8	4.9	5.8	4.8
-- Alkalinity					133	145	143	164

CAROLLO ENGINEERS, PC	
W.O./CLIENT:	8286A.00 / City of Prescott
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Calc by: CL	Date Time: 06/28/2010 4:41 PM
Chk by/Date	

Biotran-1402	MLE Ph 1 Design AADF	MLE Ph 1 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 2 Design AADF	MLE Ph 2 Design MMADF Winter	MLE Ph 4 Design AADF	MLE Ph 4 Design MMADF Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
OUTPUT FROM WAS THICKENING (OR CO-THICK)	Grav Thkr	Grav Thkr	NA	NA	GBT	GBT	GBT	GBT
o Thickened Sludge	WAS	WAS	NA	NA	WAS	WAS	WAS	WAS
- Total Solids, lb/d	5,658	11,135	12,399	24,612	4,661	12,814	9,277	25,586
- Percent Solids, %	2.0	2.0	0.9	0.8	5.0	5.0	5.0	5.0
- Flow Rate, mgd Average	0.034	0.067	0.174	0.367	0.011	0.031	0.022	0.061
- Volatile Solids, lb/d	3,591	7,401	8,190	17,133	3,382	9,617	6,725	19,196
- Organic N, lb/d	234	509	532	1,197	250	732	496	1,461
o Underflow/Filtrate/Return Flow								
- Flow, mgd	0.060	0.108	0.000	0.000	0.074	0.219	0.138	0.437
- Characteristics, mg/L								
-- BOD	280	449	0	0	149	218	158	218
-- TSS	2,010	2,190	0	0	841	781	898	781
-- VSS	1,276	1,455	0	0	610	586	651	586
-- NH3-N	0	1	0	0	0	0	0	0
-- Organic-N	83	100	0	0	47	46	50	46
-- NO3-N + NO2-N	0.0	0.0	0.0	0.0	5.8	4.9	5.8	4.8
-- Alkalinity	126	106	0	0	133	145	143	164
ANAEROBIC DIGESTION	NA	NA	NA	NA	In Service	In Service	In Service	In Service
o Digester Feed								
- Flow, total, mgd					0.087	0.141	0.174	0.283
-- Primary Sludge					0.076	0.111	0.152	0.221
-- Waste Activated Sludge					0.011	0.031	0.022	0.061
- Solids, total, lb/d					23,631	40,514	47,240	81,002
-- Primary Sludge					18,970	27,701	37,963	55,416
-- Waste Activated Sludge					4,661	12,814	9,277	25,586
-- Ratio, Primary/Total					0.80	0.68	0.80	0.68
- Volatile Solids, total, lb/d					19,459	33,067	38,900	66,111
-- Primary Sludge					16,077	23,451	32,175	46,916
-- Waste Activated Sludge					3,382	9,617	6,725	19,196
- Organic N, total, lb/d					440	1,019	877	2,034
o Digester Size								
- Smaller Size Units								
-- Number					1	1	2	2
-- Diameter, ft					85	85	85	85
-- SWD, ft					25.5	25.5	25.5	25.5
-- Volume per Digester, kcf					144.7	144.7	144.7	144.7
- Larger Size Units								
-- Number					2	2	3	3
-- Diameter, ft					85	85	85	85
-- SWD, ft					25.5	25.5	25.5	25.5
-- Volume per Digester, kcf					144.7	144.7	144.7	144.7
- Gross Volume, kcf								
-- All Units in Service					434	434	723	723
-- One Unit OOS					289	289	579	579
- Allowance for grit, percent					5	5	5	5
- Effective Volume, kcf								
-- All Units in Service					412	412	687	687
-- One Unit OOS					275	275	550	550
o Loading								
- VSS Loading, lb VSS/cf-d								
-- All Units in Service					0.047	0.080	0.057	0.096
-- One Unit OOS					0.071	0.120	0.071	0.120
- Detention Time, days								
-- All Units in Service					35.5	21.8	29.6	18.2
-- One Unit OOS					23.6	14.5	23.6	14.5

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Biotran-1402	MLE	MLE	MLE	MLE	MLE	MLE	MLE	MLE
	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 2	Ph 4	Ph 4
	Design	Design	Design	Design	Design	Design	Design	Design
	AADF	MMADF	AADF	MMADF	AADF	MMADF	AADF	MMADF
		Winter		Winter		Winter		Winter
	No digestion		No digestion		Anaerobic digestion		Anaerobic digestion	
Annual Average Plant Flow, mgd	3.75	3.75	7.50	7.50	7.50	7.50	15.00	15.00
Design (Max-Month) Flow, mgd	3.75	5.25	7.50	12.75	7.50	12.12	15.00	24.24
o Digested Sludge								
- VSS destruction, %					60	53	58	52
- VSS destroyed, lb/d					11,594	17,400	22,552	34,170
- Digested Sludge Flow Rate, mgd					0.086	0.139	0.171	0.279
- Discharge Total Solids, lb/d					12,037	23,115	24,687	46,832
-- TSS, %					1.69	1.99	1.73	2.01
-- VSS, %					65.3	67.8	66.2	68.2
o Gas Production								
- cf/lb VSS destroyed					15	15	15	15
- Gas Production, kcf/d					174	261	338	513
o Nitrogen in Dig Sludge Filtrate								
- Assumed Sol OrgN in Digester effl, mg/L					5	5	5	5
- Org N/VSS in Digester Solids					0.022	0.031	0.022	0.031
- VSS destroyed, lb/d					11,594	17,400	22,552	34,170
- Ammonia generated, lb/d					260	533	504	1,045
- NH3 Concentration, mg/L					393.01	485.80	381.38	476.67
- Alkalinity, mg/L					1,182	2,158	2,062	4,006
o Digested Sludge Routing					Dewat	Dewat	Dewat	Dewat
CENTRIFUGE DEWATERING	In Service	In Service	In Service	In Service	In Service	In Service	In Service	In Service
Select dewatering method under "Feed to Dewatering"								
o Sludge Feed								
- Flow Rate, mgd	0.034	0.067	0.174	0.367	0.086	0.139	0.171	0.279
- Total Solids, lb/d	5,658	11,135	12,399	24,612	12,037	23,115	24,687	46,832
- Total VSS, lb/d	3,591	7,401	8,190	17,133	7,865	15,667	16,348	31,942
o Number of Centrifuges	2	2	3	3	3	3	3	3
- Number of Units in Service	2	2	2	2	2	2	2	2
- Feed Rate, gpm per unit	70	70	200	200	200	200	200	200
- Operating cycle								
-- days/week	6	7	6	7	6	6	6	6
-- hours/day (calc)	4.7	7.9	8.4	15.3	4.2	6.8	8.3	13.5
o Sludge Cake								
- Capture, %	95	95	95	95	95	95	95	95
- Concentration, %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
- Cake Solids, lb/d								
-- Dry Solids, lb/d	5,375	10,578	11,780	23,381	11,435	21,959	23,453	44,490
-- Wet Cake, tons/d	13.4	26.4	29.4	58.5	28.6	54.9	58.6	111.2
- Flow, mgd	0.0032	0.0063	0.0071	0.0140	0.0069	0.0132	0.0141	0.0267
o Dewatering Centrate								
- Flow, mgd	0.031	0.060	0.167	0.353	0.079	0.126	0.157	0.252
- Characteristics, mg/L								
-- BOD	242	341	1	1	770	781	771	782
-- TSS	1,105	1,105	446	419	916	1,098	941	1,114
-- VSS	701	734	295	291	599	744	623	760
-- NH3-N	0	1	0	0	393	486	381	477
-- Organic-N	47	52	21	22	18	28	19	28
-- NO3-N + NO2-N	5	5	4	3	0	0	0	0
-- Alkalinity	126	106	142	155	1,182	2,158	2,062	4,006
-- Filterable ("soluble") BOD	1	1	1	1	700	700	700	700
-- Total soluble Organic N	2	2	2	2	5	5	5	5

Appendix B

Detailed Capital Costs and Operating Costs

CAPITAL COST ESTIMATE

BUILDOUT (15 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

		Estimate Class:	4
Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	PIC:	J. Doller
Job #:	8286A.00	PM:	M. Courtney
Location:	Prescott, AZ	Date:	June 17, 2010
Zip Code:	86301	By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION		TOTAL
01	General Conditions		$14,467,000
02	Headworks/Screening		$1,574,000
03	Grit Removal		$1,467,000
04	Splitter Boxes		$635,000
05	Primary Clarification		$6,652,000
06	Aeration System		$11,712,000
07	Blower Building		$3,624,000
08	Secondary Clarification		$10,278,000
09	RAS/WAS Pump Station		$706,000
10	Tertiary Filtration		$6,209,000
11	UV Disinfection		$8,174,000
12	Effluent Pump Station		$537,000
13	Solids Handling		$9,920,000
14	Anaerobic Digesters		$18,400,000
15	Administration / Maintenance Building		$1,731,000
16	Odor Control		$4,490,000
17	Miscellaneous Onsite		$10,334,000
	TOTAL DIRECT COST		**$110,910,000**
	Contingency	20.0%	$22,182,000
	Subtotal		**$133,092,000**
	General Contractor Overhead, Profit & Risk	15.0%	$19,963,800
	Subtotal		**$153,055,800**
	Escalation to Mid-Point	0.0%	$0
	Subtotal		**$153,055,800**
	Sales Tax	5.0%	$7,652,790
	Subtotal		**$160,708,590**
	Bid Market Allowance	0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST		**$160,708,590**

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	**GENERAL CONDITIONS**	0.15	%	96,443,000	14,466,450	1.00	14,466,450
						SUBTOTAL	*$ 14,466,450*
2	**HEADWORKS/ SCREENING**						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	800
	Structural Backfill	13	CY	40	533	1.00	533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	150,400
	Headworks Building	3,200	SF	150	480,000	1.00	480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	2	EA	190,821	381,642	1.00	381,642
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	61,800
	Misc. Mechanical (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	103,683
	Misc. Electrical (20% of equip)	0.20	%	443,442	88,688	1.00	88,688
	Misc. I&C (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
						SUBTOTAL	*$ 1,573,713*
3	**GRIT REMOVAL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	282	CY	800	225,600	1.00	225,600
	Misc. Metals, Wood & Plastics, Finishes,	1	LS	149,289	149,289	1.00	149,289
	PROCESS / MECHANICAL						
	Vortex Grit System	3	EA	242,486	727,459	1.00	727,459
	Misc. Mechanical (15% of equip)	0.15	%	727,459	109,119	1.00	109,119
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	727,459	145,492	1.00	145,492
	Misc. I&C (15% of equip)	0.15	%	727,459	109,119	1.00	109,119
						SUBTOTAL	*$ 1,466,077*
4	**SPLITTER BOX**						
	CIVIL / SITE WORK						
	Excavation (soil)	5,348	CY	15	80,215	1.00	80,215
	Backfill (soil)	3,473	CY	20	69,450	1.00	69,450
	Structural Backfill	139	CY	40	5,556	1.00	5,556

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	300	CY	800	240,000	1.00	240,000
	Misc. Metals	3	LS	15,902	47,705	1.00	47,705
	Misc. FRP Weirs	120	LF	90	10,824	1.00	10,824
	PROCESS / MECHANICAL						
	Stainless Steel Gates	14	EA	8,589	120,247	1.00	120,247
	Misc. Mechanical (15% of equip)	0.15	%	120,247	18,037	1.00	18,037
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	120,247	24,049	1.00	24,049
	Misc. I&C (15% of equip)	0.15	%	120,247	18,037	1.00	18,037
						SUBTOTAL	***$ 634,121***
5	**PRIMARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	25,866	CY	15	387,996	1.00	387,996
	Backfill (soil)	9,482	CY	20	189,645	1.00	189,645
	Structural Backfill	1,489	CY	40	59,579	1.00	59,579
	ARCHITECTURAL / STRUCTURAL						
	Clarifier - Concrete	2,388	CY	800	1,910,336	1.00	1,910,336
	Sludge PS - Concrete	194	CY	600	116,670	1.00	116,670
	Clarifier Dome Covers	4	EA	290,000	1,160,000	1.00	1,160,000
	FRP Weirs & Baffles	4	LS	25,000	100,000	1.00	100,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	4	EA	400,000	1,600,000	1.10	1,760,000
	Sludge Pumps	2	EA	39,150	78,299	1.10	86,129
	Scum Pumps	2	EA	13,050	26,100	1.10	28,710
	Misc. Mechanical (15% of equip)	0.15	%	1,704,399	170,440	1.00	170,440
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,704,399	340,880	1.00	340,880
	Misc. I&C (15% of equip)	0.15	%	1,704,399	340,880	1.00	340,880
						SUBTOTAL	***$ 6,651,264***
6	**AERATION SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	108,775	CY	15	1,631,619	1.00	1,631,619
	Backfill (soil)	19,790	CY	20	395,795	1.00	395,795
	Structural Backfill	8,475	CY	40	338,990	1.00	338,990
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	10,240	CY	600	6,143,956	1.00	6,143,956

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	Submersible Mixers	8	EA	79,337	634,700	1.00	634,700
	MLR Pumps	8	EA	51,470	411,761	1.00	411,761
	Fine Bubble Diffuser System	4	LS	271,988	1,087,953	1.00	1,087,953
	Misc. Mechanical (15% of equip)	0.15	LS	2,134,414	320,162	1.00	320,162
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,134,414	426,883	1.00	426,883
	Misc. I&C (15% of equip)	0.15	%	2,134,414	320,162	1.00	320,162
						SUBTOTAL	***$ 11,711,981***
7	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	40	CY	15	600	1.00	600
	Structural Backfill	10	CY	40	400	1.00	400
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,800	SF	150	270,000	1.00	270,000
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	5	EA	429,940	2,149,701	1.00	2,149,701
	Misc. Mechanical (15% of equip)	0.15	%	2,149,701	322,455	1.00	322,455
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,800	SF	39	69,986	1.00	69,986
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,800	SF	32	58,322	1.00	58,322
	Misc. Electrical (20% of equip)	0.20	%	2,149,701	429,940	1.00	429,940
	Misc. I&C (15% of equip)	0.15	%	2,149,701	322,455	1.00	322,455
						SUBTOTAL	***$ 3,623,860***
8	**SECONDARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	56,180	CY	15	842,693	1.00	842,693
	Backfill (soil)	17,779	CY	20	355,584	1.00	355,584
	Structural Backfill	3,491	CY	40	139,638	1.00	139,638
	ARCHITECTURAL / STRUCTURAL						
	Secondary Clarifiers - Concrete	6,150	CY	800	4,920,000	1.00	4,920,000
	Misc. FRP Baffles and Weirs	6	EA	25,000	150,000	1.00	150,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	6	EA	430,000	2,580,000	1.00	2,580,000
	Misc. Mechanical (15% of equip)	0.15	%	2,580,000	387,000	1.00	387,000
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,580,000	516,000	1.00	516,000
	Misc. I&C (15% of equip)	0.15	%	2,580,000	387,000	1.00	387,000
						SUBTOTAL	***$ 10,277,914***

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
9	**RAS WAS PUMP STATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	23,150
	Structural Backfill	46	CY	40	1,852	1.00	1,852
	ARCHITECTURAL / STRUCTURAL						
	RAS P. S. - Slab/Footing	35	CY	580	20,300	1.00	20,300
	RAS P. S. - Walls	116	CY	710	82,360	1.00	82,360
	RAS P. S. - Elevated Slab	35	CY	840	29,169	1.00	29,169
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	RAS Pumps	4	EA	61,120	244,480	1.00	244,480
	WAS Pumps	3	EA	17,060	51,180	1.00	51,180
	Scum Pumps	6	EA	7,000	42,000	1.00	42,000
	Misc. Mechanical (15% of equip)	0.15	LS	337,660	50,649	1.00	50,649
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	337,660	67,532	1.00	67,532
	Misc. I&C (15% of equip)	0.15	%	337,660	50,649	1.00	50,649
						SUBTOTAL	***$ 705,059***
10	**TERTIARY FILTRATION**						
	CIVIL / SITE WORK						
	Excavation and backfill	1	LS	160,221	160,221	1.00	160,221
	ARCHITECTURAL / STRUCTURAL						
	Filter basins and channels - walls	484	CY	830	401,720	1.00	401,720
	Filter basins and channels - slabs	270	CY	520	140,400	1.00	140,400
	Misc - Metals	1	LS	290,693	290,693	1.00	290,693
	PROCESS / MECHANICAL						
	Disk Filters Equipment	1	LS	3,233,337	3,233,337	1.00	3,233,337
	Chemical feed	1	LS	82,056	82,056	1.00	82,056
	Filter Inlet gates	10	EA	8,002	80,020	1.00	80,020
	Channel gates	3	EA	15,450	46,350	1.00	46,350
	Effluent weir gate	1	EA	16,450	16,450	1.00	16,450
	Sump pump	1	EA	18,616	18,616	1.00	18,616
	Misc. Mechanical (15% of equip)	0.15	%	3,476,829	521,524	1.00	521,524
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	3,476,829	695,366	1.00	695,366
	Misc. I&C (15% of equip)	0.15	%	3,476,829	521,524	1.00	521,524
						SUBTOTAL	***$ 6,208,277***

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
11	**DISINFECTION**						
	CIVIL / SITE WORK						
	Excavation (soil)	648	CY	15	9,727	1.00	9,727
	Backfill (soil)	264	CY	20	5,288	1.00	5,288
	Structural Backfill	107	CY	40	4,267	1.00	4,267
	ARCHITECTURAL / STRUCTURAL						
	UV Channels - Slab/Footing	53	CY	580	30,936	1.00	30,936
	UV Channels - Walls	53	CY	710	37,743	1.00	37,743
	PROCESS / MECHANICAL						
	UV Equipment	16	LS	336,914	5,390,625	1.00	5,390,625
	Misc. Mechanical (15% of equip)	0.15	LS	5,390,625	808,594	1.00	808,594
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	5,390,625	1,078,125	1.00	1,078,125
	Misc. I&C (15% of equip)	0.15	%	5,390,625	808,594	1.00	808,594
						SUBTOTAL	***$ 8,173,899***
12	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	32,410
	Structural Backfill	74	CY	40	2,963	1.00	2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	96,000
	PROCESS / MECHANICAL						
	Effluent Pumps	5	EA	44,632	223,162	1.00	223,162
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	Misc. Mechanical (15% of equip)	0.15	LS	238,162	35,724	1.00	35,724
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	238,162	47,632	1.00	47,632
	Misc. I&C (15% of equip)	0.15	%	238,162	44,632	1.00	44,632
						SUBTOTAL	***$ 536,832***
13	**SOLIDS HANDLING**						
	CIVIL / SITE WORK						
	Excavation (soil)	120	CY	15	1,800	1.00	1,800
	Structural Backfill	30	CY	40	1,200	1.00	1,200
	ARCHITECTURAL / STRUCTURAL						
	Solids Handling Building	16,991	SF	150	2,548,650	1.00	2,548,650

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	PROCESS / MECHANICAL						
	Gravity Belt Thickeners	3	EA	237,149	711,448	1.00	711,448
	Thickened Sludge Pumps	4	EA	20,154	80,617	1.00	80,617
	Polymer System - Thickening	1	LS	188,730	188,730	1.00	188,730
	Dewatering Centrifuge	3	EA	771,131	2,313,392	1.00	2,313,392
	Classifiers, Hoppers, Conveyors	1	EA	750,000	750,000	1.00	750,000
	Centrifuge Feed Pumps	3	EA	20,154	60,463	1.00	60,463
	Misc. Mechanical (15% of equip)	0.15	LS	4,104,649	615,697	1.00	615,697
	HVAC / PLUMBING / FIRE PROTECTION						
	Solids Handling Building	16,991	SF	39	660,631	1.00	660,631
	ELECTRICAL / INSTRUMENTATION						
	Solids Handling Building	16,991	SF	32	550,526	1.00	550,526
	Misc. Electrical (20% of equip)	0.20	%	4,104,649	820,930	1.00	820,930
	Misc. I&C (15% of equip)	0.15	%	4,104,649	615,697	1.00	615,697
						SUBTOTAL	***$ 9,919,781***
14	**ANAEROBIC DIGESTION**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	Anaerobic Digesters	1	LS	18,400,000	18,400,000	1.00	18,400,000
						SUBTOTAL	***$ 18,400,000***
15	**ADMINISTRATION BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	80	CY	15	1,200	1.00	1,200
	Structural Backfill	20	CY	40	800	1.00	800
	ARCHITECTURAL / STRUCTURAL						
	Building	7,200	SF	150	1,080,000	1.00	1,080,000
	PROCESS / MECHANICAL						
	Maintenance Specialty Items	1	LS	100,000	100,000	1.00	100,000
	HVAC / PLUMBING / FIRE PROTECTION						
	Admin Building	7,200	SF	39	279,945	1.00	279,945
	ELECTRICAL / INSTRUMENTATION						
	Admin Building	7,200	SF	32	233,288	1.00	233,288
	Misc. Electrical (20% of process)	0.20	%	100,000	20,000	1.00	20,000
	Misc. I&C (15% of equip)	0.15	%	100,000	15,000	1.00	15,000
						SUBTOTAL	***$ 1,730,233***

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - BUILDOUT (15 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
16	**ODOR CONTROL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Primary Odor Control System (Headworks,	1	LS	940,369	940,369	1.00	940,369
	Solids Handling Odor Control System	1	LS	2,052,499	2,052,499	1.00	2,052,499
	Misc. Mechanical (15% of equip)	0.15	LS	2,992,867	448,930	1.00	448,930
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of process)	0.20	%	2,992,867	598,573	1.00	598,573
	Misc. I&C (15% of equip)	0.15	%	2,992,867	448,930	1.00	448,930
						SUBTOTAL	***$ 4,489,301***
17	**MISCELLANEOUS ONSITE**						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	86,109,000	10,333,080	1.00	10,333,080
						SUBTOTAL	***$ 10,333,080***

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

OPERATIONS AND MAINTENANCE COSTS ESTIMATE

BUILDOUT (15 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

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AIRPORT WATER RECLAMATION FACILITY
CENTRALIZED TREATMENT ALTERNATIVE (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - BUILDOUT (15 MGD)

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	April 27, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	DESCRIPTION	Total Cost
1	ANNUAL POWER COSTS	$2,286,000
2	ANNUAL CHEMICAL COSTS	$767,000
3	ANNUAL LABOR COSTS	$660,000
4	ANNUAL MISCELLANEOUS COSTS	$1,016,000
	ESTIMATED ANNUAL O&M TOTAL	**$4,729,000**
	PRESENT WORTH FACTOR	***13.74***
	O&M PRESENT WORTH COST TOTAL	**$64,961,747**

NOTES

1. Present worth factor annual interest rate = 6%
2. Present worth factor annual inflation rate = 2%
3. Present worth factor planning period (yrs) = 20

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - BUILDOUT (15 MGD)

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	April 27, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**ANNUAL POWER COSTS**					
	Headworks	626,189	kW-hr	0.10	62,600	$62,600
	Primary Treatment	323,356	kW-hr	0.10	32,300	$32,300
	Secondary Treatment	7,015,346	kW-hr	0.10	701,500	$701,500
	Tertiary Filtration	65,934	kW-hr	0.10	6,600	$6,600
	UV Disinfection System	2,837,419	kW-hr	0.10	283,700	$283,700
	Effluent Pumping System	591,703	kW-hr	0.10	59,200	$59,200
	Sludge Thickening	348,993	kW-hr	0.10	34,900	$34,900
	Sludge Digestion	2,781,408	kW-hr	0.10	278,100	$278,100
	Sludge Dewatering	1,744,036	kW-hr	0.10	174,400	$174,400
	Solids Handling Building	1,655,158	kW-hr	0.10	165,500	$165,500
	Administration Building	668,563	kW-hr	0.10	66,900	$66,900
	Odor Control	4,195,717	kW-hr	0.10	419,600	$419,600
					ANNUAL POWER COST SUBTOTAL	***$2,285,300***
2	**ANNUAL CHEMICAL COSTS**					
	Disk Filters	1	LS	-	8,000	$8,000
	Chemicals (Caustic, Sodium Hypochlorite, Ferrous Chloride)	1	LS	-	467,200	$467,200
	Emulsion Polymer, Active	141,438	lb	1.85	261,700	$261,700
	Hydrochloric Acid	1	LS	--	10,000	$10,000
	Diesel Fuel	1	LS	--	15,000	$15,000
	Oils and Lubricants	1	LS	--	5,000	$5,000
					ANNUAL CHEMICAL COST SUBTOTAL	***$766,900***
3	**ANNUAL LABOR COSTS (including 32% for benefits)**					
	Operators	7	staff	60,000	420,000	$420,000
	Mechanical	1	staff	65,000	65,000	$65,000
	Supervisor	1	staff	75,000	75,000	$75,000
	Electrical/Instrumentation	1	staff	65,000	65,000	$65,000
	Administration	1	staff	35,000	35,000	$35,000
					ANNUAL LABOR SUBTOTAL	***$660,000***
4	**ANNUAL MISCELLANEOUS COSTS**					
	Disk Filters - Maintenance	1	LS	-	21,400	$21,400
	Annual UV Lamp Replacement Cost	1	LS	-	218,400	$218,400
	Off-Site Sludge Disposal	22,356	wet ton	15.00	335,300	$335,300
	Off-Site Screenings/Grit Disposal	1	LS	--	8,000	$8,000
	General Parts and Supplies	1	LS	--	30,000	$30,000
	Communication Charges	12	months	1,300	15,600	$15,600
	Potable Water Charges	12	months	1,000	12,000	$12,000
	Major Process Parts Replacement	1	LS	--	175,000	$175,000
	Centrifuge Maintenance Services Contract	1	LS	--	50,000	$50,000
	Generator Maintenance Services Contract	1	LS	--	100,000	$100,000
	Miscellaneous	1	LS	--	50,000	$50,000
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$1,015,700***

CAPITAL COST ESTIMATE

PHASE 2 (7.5 MGD, NO DIGESTION)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

		Estimate Class:	4
Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	PIC:	J. Doller
Job #:	8286A.00	PM:	M. Courtney
Location:	Prescott, AZ	Date:	June 17, 2010
Zip Code:	86301	By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION		TOTAL
01	General Conditions		$6,161,000
02	Headworks/Screening		$1,574,000
03	Grit Removal		$978,000
04	Splitter Boxes		$393,000
05	Primary Clarification		$0
06	Aeration System		$11,404,000
07	Blower Building		$2,979,000
08	Secondary Clarification		$5,139,000
09	RAS/WAS Pump Station		$468,000
10	Tertiary Filtration		$3,908,000
11	UV Disinfection		$4,096,000
12	Effluent Pump Station		$387,000
13	Solids Handling		$3,086,000
14	Anaerobic Digesters		$0
15	Administration / Maintenance Building		$1,731,000
16	Odor Control		$529,000
17	Miscellaneous Onsite		$4,401,000
	TOTAL DIRECT COST		**$47,234,000**
	Contingency	20.0%	$9,446,800
	Subtotal		**$56,680,800**
	General Contractor Overhead, Profit & Risk	15.0%	$8,502,120
	Subtotal		**$65,182,920**
	Escalation to Mid-Point	0.0%	$0
	Subtotal		**$65,182,920**
	Sales Tax	5.0%	$3,259,146
	Subtotal		**$68,442,066**
	Bid Market Allowance	0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST		**$68,442,066**

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	GENERAL CONDITIONS	0.15	%	41,073,000	6,160,950	1.00	6,160,950
						SUBTOTAL	*$ 6,160,950*
2	HEADWORKS/ SCREENING						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	800
	Structural Backfill	13	CY	40	533	1.00	533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	150,400
	Headworks Building	3,200	SF	150	480,000	1.00	480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	2	EA	190,821	381,642	1.00	381,642
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	61,800
	Misc. Mechanical (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	103,683
	Misc. Electrical (20% of equip)	0.20	%	443,442	88,688	1.00	88,688
	Misc. I&C (15% of equip)	0.15	%	443,442	66,516	1.00	66,516
						SUBTOTAL	*$ 1,573,713*
3	GRIT REMOVAL						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	188	CY	800	150,400	1.00	150,400
	Misc. Metals, Wood & Plastics, Finishes,	1	LS	99,526	99,526	1.00	99,526
	PROCESS / MECHANICAL						
	Vortex Grit System	2	EA	242,486	484,972	1.00	484,972
	Misc. Mechanical (15% of equip)	0.15	%	484,972	72,746	1.00	72,746
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	484,972	96,994	1.00	96,994
	Misc. I&C (15% of equip)	0.15	%	484,972	72,746	1.00	72,746
						SUBTOTAL	*$ 977,385*
4	SPLITTER BOX						
	CIVIL / SITE WORK						
	Excavation (soil)	3,565	CY	15	53,477	1.00	53,477
	Backfill (soil)	2,315	CY	20	46,300	1.00	46,300
	Structural Backfill	93	CY	40	3,704	1.00	3,704

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	200	CY	800	160,000	1.00	160,000
	Misc. Metals	2	LS	15,902	31,804	1.00	31,804
	Misc. FRP Weirs	80	LF	90	7,216	1.00	7,216
	PROCESS / MECHANICAL						
	Stainless Steel Gates	7	EA	8,589	60,124	1.00	60,124
	Misc. Mechanical (15% of equip)	0.15	%	60,124	9,019	1.00	9,019
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	60,124	12,025	1.00	12,025
	Misc. I&C (15% of equip)	0.15	%	60,124	9,019	1.00	9,019
						SUBTOTAL	***$ 392,685***
5	**PRIMARY CLARIFICATION**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	***$ -***
6	**AERATION SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	108,775	CY	15	1,631,619	1.00	1,631,619
	Backfill (soil)	19,790	CY	20	395,795	1.00	395,795
	Structural Backfill	8,475	CY	40	338,990	1.00	338,990
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	10,240	CY	600	6,143,956	1.00	6,143,956
	PROCESS / MECHANICAL						
	Submersible Mixers	8	EA	79,337	634,700	1.00	634,700
	MLR Pumps	4	EA	51,470	205,880	1.00	205,880
	Fine Bubble Diffuser System	4	LS	271,988	1,087,953	1.00	1,087,953
	Misc. Mechanical (15% of equip)	0.15	LS	1,928,534	289,280	1.00	289,280
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,928,534	385,707	1.00	385,707
	Misc. I&C (15% of equip)	0.15	%	1,928,534	289,280	1.00	289,280
						SUBTOTAL	***$ 11,403,160***
7	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	40	CY	15	600	1.00	600
	Structural Backfill	10	CY	40	400	1.00	400
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,800	SF	150	270,000	1.00	270,000
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	4	EA	429,940	1,719,761	1.00	1,719,761
	Misc. Mechanical (15% of equip)	0.15	%	1,719,761	257,964	1.00	257,964

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,800	SF	39	69,986	1.00	69,986
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,800	SF	32	58,322	1.00	58,322
	Misc. Electrical (20% of equip)	0.20	%	1,719,761	343,952	1.00	343,952
	Misc. I&C (15% of equip)	0.15	%	1,719,761	257,964	1.00	257,964
						SUBTOTAL	*$ 2,978,950*
8	**SECONDARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	28,090	CY	15	421,346	1.00	421,346
	Backfill (soil)	8,890	CY	20	177,792	1.00	177,792
	Structural Backfill	1,745	CY	40	69,819	1.00	69,819
	ARCHITECTURAL / STRUCTURAL						
	Secondary Clarifiers - Concrete	3,075	CY	800	2,460,000	1.00	2,460,000
	Misc. FRP Baffles and Weirs	3	EA	25,000	75,000	1.00	75,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	3	EA	430,000	1,290,000	1.00	1,290,000
	Misc. Mechanical (15% of equip)	0.15	%	1,290,000	193,500	1.00	193,500
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,290,000	258,000	1.00	258,000
	Misc. I&C (15% of equip)	0.15	%	1,290,000	193,500	1.00	193,500
						SUBTOTAL	*$ 5,138,957*
9	**RAS WAS PUMP STATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	23,150
	Structural Backfill	46	CY	40	1,852	1.00	1,852
	ARCHITECTURAL / STRUCTURAL						
	RAS P. S. - Slab/Footing	35	CY	580	20,300	1.00	20,300
	RAS P. S. - Walls	116	CY	710	82,360	1.00	82,360
	RAS P. S. - Elevated Slab	35	CY	840	29,169	1.00	29,169
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	RAS Pumps	3	EA	40,740	122,220	1.00	122,220
	WAS Pumps	3	EA	11,940	35,820	1.00	35,820
	Scum Pumps	3	EA	7,000	21,000	1.00	21,000
	Misc. Mechanical (15% of equip)	0.15	LS	179,040	26,856	1.00	26,856
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	179,040	35,808	1.00	35,808
	Misc. I&C (15% of equip)	0.15	%	179,040	26,856	1.00	26,856
						SUBTOTAL	*$ 467,129*

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
10	TERTIARY FILTRATION						
	CIVIL / SITE WORK						
	Excavation and backfill	1	LS	160,221	160,221	1.00	160,221
	ARCHITECTURAL / STRUCTURAL						
	Filter basins and channels - walls	296	CY	830	245,680	1.00	245,680
	Filter basins and channels - slabs	192	CY	520	99,840	1.00	99,840
	Misc - Metals	1	LS	174,416	174,416	1.00	174,416
	PROCESS / MECHANICAL						
	Disk Filters Equipment	1	LS	1,940,002	1,940,002	1.00	1,940,002
	Chemical feed	1	LS	82,056	82,056	1.00	82,056
	Filter Inlet gates	6	EA	8,002	48,012	1.00	48,012
	Channel gates	3	EA	15,450	46,350	1.00	46,350
	Effluent weir gate	1	EA	16,450	16,450	1.00	16,450
	Sump pump	1	EA	18,616	18,616	1.00	18,616
	Misc. Mechanical (15% of equip)	0.15	%	2,151,486	322,723	1.00	322,723
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,151,486	430,297	1.00	430,297
	Misc. I&C (15% of equip)	0.15	%	2,151,486	322,723	1.00	322,723
						SUBTOTAL	***$ 3,907,386***
11	DISINFECTION						
	CIVIL / SITE WORK						
	Excavation (soil)	324	CY	15	4,863	1.00	4,863
	Backfill (soil)	132	CY	20	2,644	1.00	2,644
	Structural Backfill	53	CY	40	2,134	1.00	2,134
	ARCHITECTURAL / STRUCTURAL						
	UV Channels - Slab/Footing	27	CY	580	15,468	1.00	15,468
	UV Channels - Walls	39	CY	710	27,897	1.00	27,897
	PROCESS / MECHANICAL						
	UV Equipment	8	LS	336,914	2,695,313	1.00	2,695,313
	Misc. Mechanical (15% of equip)	0.15	LS	2,695,313	404,297	1.00	404,297
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	2,695,313	539,063	1.00	539,063
	Misc. I&C (15% of equip)	0.15	%	2,695,313	404,297	1.00	404,297
						SUBTOTAL	***$ 4,095,975***

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
12	EFFLUENT PUMPING						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	32,410
	Structural Backfill	74	CY	40	2,963	1.00	2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	3	EA	44,632	133,897	1.00	133,897
	Misc. Mechanical (15% of equip)	0.15	LS	133,897	20,085	1.00	20,085
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	133,897	26,779	1.00	26,779
	Misc. I&C (15% of equip)	0.15	%	133,897	20,085	1.00	20,085
						SUBTOTAL	***$ 386,527***
13	SOLIDS HANDLING						
	CIVIL / SITE WORK						
	Excavation (soil)	89	CY	15	1,333	1.00	1,333
	Structural Backfill	22	CY	40	889	1.00	889
	ARCHITECTURAL / STRUCTURAL						
	Solids Handling Building	2,400	SF	150	360,000	1.00	360,000
	Misc. Metals	2	LS	20,000	40,000	1.00	40,000
	PROCESS / MECHANICAL						
	Dewatering Centrifuge Package	5	EA	335,000	1,675,000	1.00	1,675,000
	Misc. Mechanical (15% of equip)	0.15	LS	1,675,000	251,250	1.00	251,250
	HVAC / PLUMBING / FIRE PROTECTION						
	Solids Handling Building	2,400	SF	39	93,600	1.00	93,600
	ELECTRICAL / INSTRUMENTATION						
	Solids Handling Building	2,400	SF	32	76,800	1.00	76,800
	Misc. Electrical (20% of equip)	0.20	%	1,675,000	335,000	1.00	335,000
	Misc. I&C (20% of equip)	0.15	%	1,675,000	251,250	1.00	251,250
						SUBTOTAL	***$ 3,085,122***
14	ANAEROBIC DIGESTION						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	***$ -***
15	ADMINISTRATION BUILDING						
	CIVIL / SITE WORK						
	Excavation (soil)	80	CY	15	1,200	1.00	1,200
	Structural Backfill	20	CY	40	800	1.00	800
	ARCHITECTURAL / STRUCTURAL						
	Building	7,200	SF	150	1,080,000	1.00	1,080,000
	PROCESS / MECHANICAL						
	Maintenance Specialty Items	1	LS	100,000	100,000	1.00	100,000
	HVAC / PLUMBING / FIRE PROTECTION						
	Admin Building	7,200	SF	39	279,945	1.00	279,945
	ELECTRICAL / INSTRUMENTATION						
	Admin Building	7,200	SF	32	233,288	1.00	233,288
	Misc. Electrical (20% of process)	0.20	%	100,000	20,000	1.00	20,000
	Misc. I&C (15% of equip)	0.15	%	100,000	15,000	1.00	15,000
						SUBTOTAL	***$ 1,730,233***

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 2 (7.5 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	SS/CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
16	**ODOR CONTROL**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Primary Odor Control System	1	LS	352,638	352,638	1.00	352,638
	Misc. Mechanical (15% of equip)	0.15	LS	352,638	52,896	1.00	52,896
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of process)	0.20	%	352,638	70,528	1.00	70,528
	Misc. I&C (15% of equip)	0.15	%	352,638	52,896	1.00	52,896
						SUBTOTAL	***$ 528,957***
17	**MISCELLANEOUS ONSITE**						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	36,672,000	4,400,640	1.00	4,400,640
						SUBTOTAL	***$ 4,400,640***

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

OPERATIONS AND MAINTENANCE COSTS ESTIMATE

PHASE 2 (7.5 MGD, NO DIGESTION)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

carollo

AIRPORT WATER RECLAMATION FACILITY
CENTRALIZED TREATMENT PROCESS (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - 7.5 MGD WITHOUT DIGESTION

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	May 14, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	DESCRIPTION	Total Cost
1	ANNUAL POWER COSTS	$1,128,000
2	ANNUAL CHEMICAL COSTS	$326,000
3	ANNUAL LABOR COSTS	$540,000
4	ANNUAL MISCELLANEOUS COSTS	$658,000
	ESTIMATED ANNUAL O&M TOTAL	**$2,652,000**
	PRESENT WORTH FACTOR	***13.74***
	O&M PRESENT WORTH COST TOTAL	**$36,430,229**

NOTES

1. Present worth factor annual interest rate = 6%
2. Present worth factor annual inflation rate = 2%
3. Present worth factor planning period (yrs) = 20

Carollo

AIRPORT WATER RECLAMATION FACILITY
CENTRALIZED TREATMENT PROCESS (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - 7.5 MGD WITHOUT DIGESTION

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	May 14, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**ANNUAL POWER COSTS**					
	Headworks	639,254	kW-hr	0.10	63,900	$63,900
	Primary Treatment	0	kW-hr	0.10	-	$0
	Secondary Treatment	5,651,103	kW-hr	0.10	565,100	$565,100
	Tertiary Filtration	32,967	kW-hr	0.10	3,300	$3,300
	UV Disinfection System	1,418,709	kW-hr	0.10	141,900	$141,900
	Effluent Pumping System	295,851	kW-hr	0.10	29,600	$29,600
	Sludge Thickening	0	kW-hr	0.10	-	$0
	Sludge Digestion	0	kW-hr	0.10	-	$0
	Sludge Dewatering	868,993	kW-hr	0.10	86,900	$86,900
	Solids Handling Building	827,579	kW-hr	0.10	82,800	$82,800
	Odor Control	1,536,957	kW-hr	0.10	153,700	$153,700
					ANNUAL POWER COST SUBTOTAL	***$1,127,200***
2	**ANNUAL CHEMICAL COSTS**					
	Disk Filters	1	LS	-	3,900	$3,900
	Chemicals (Caustic, Sodium Hypochlorite, Ferrous Chloride)	1	LS	-	233,600	$233,600
	Emulsion Polymer, Active	35,074	lb	1.85	64,900	$64,900
	Hydrochloric Acid	1	LS	--	7,800	$7,800
	Diesel Fuel	1	LS	--	11,700	$11,700
	Oils and Lubricants	1	LS	--	3,900	$3,900
					ANNUAL CHEMICAL COST SUBTOTAL	***$325,800***
3	**ANNUAL LABOR COSTS (including 32% for benefits)**					
	Operators	5	staff	60,000	300,000	$300,000
	Mechanical	1	staff	65,000	65,000	$65,000
	Supervisor	1	staff	75,000	75,000	$75,000
	Electrical/Instrumentation	1	staff	65,000	65,000	$65,000
	Administration	1	staff	35,000	35,000	$35,000
					ANNUAL LABOR SUBTOTAL	***$540,000***
4	**ANNUAL MISCELLANEOUS COSTS**					
	Disk Filters - Maintenance	1	LS	-	10,700	$10,700
	Annual UV Lamp Replacement Cost	1	LS	-	128,000	$128,000
	Off-Site Sludge Disposal	11,036	wet ton	15.00	165,500	$165,500
	Off-Site Screenings/Grit Disposal	1	LS	--	6,000	$6,000
	General Parts and Supplies	1	LS	--	25,000	$25,000
	Communication Charges	12	months	1,300	15,600	$15,600
	Potable Water Charges	12	months	600	7,200	$7,200
	Major Process Parts Replacement	1	LS	--	100,000	$100,000
	Centrifuge Maintenance Services Contract	1	LS	--	50,000	$50,000
	Generator Maintenance Services Contract	1	LS	--	100,000	$100,000
	Miscellaneous	1	LS	--	50,000	$50,000
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$658,000***

CAPITAL COST ESTIMATE

PHASE 1 (3.75 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

		Estimate Class:	4
Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	PIC:	J. Doller
Job #:	8286A.00	PM:	M. Courtney
Location:	Prescott, AZ	Date:	June 17, 2010
Zip Code:	86301	By:	C. Lopez
		Reviewed:	C. Meyer

NO.	DESCRIPTION			TOTAL
01	General Conditions			$2,951,000
02	Headworks/Screening			$1,288,000
03	Grit Removal			$489,000
04	Splitter Boxes			$355,000
05	Primary Clarification			$0
06	Aeration System			$6,587,000
07	Blower Building			$2,016,000
08	Secondary Clarification			$3,426,000
09	RAS/WAS Pump Station			$378,000
10	Tertiary Filtration			$1,906,000
11	UV Disinfection			$2,072,000
12	Effluent Pump Station			$283,000
13	Solids Handling			$523,000
14	Anaerobic Digesters			$0
15	Administration / Maintenance Building			$0
16	Odor Control			$353,000
17	Miscellaneous Onsite			$2,361,000
		TOTAL DIRECT COST		**$24,988,000**
	Contingency		20.0%	$4,997,600
		Subtotal		**$29,985,600**
	General Contractor Overhead, Profit & Risk		15.0%	$4,497,840
		Subtotal		**$34,483,440**
	Escalation to Mid-Point		0.0%	$0
		Subtotal		**$34,483,440**
	Sales Tax		5.0%	$1,724,172
		Subtotal		**$36,207,612**
	Bid Market Allowance		0.0%	$0
	TOTAL ESTIMATED CONSTRUCTION COST			**$36,207,612**

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
1	GENERAL CONDITIONS	0.15	%	19,671,247	2,950,687	1.00	2,950,687
					SUBTOTAL	$	2,950,687
2	HEADWORKS/ SCREENING						
	CIVIL / SITE WORK						
	Excavation (soil)	53	CY	15	800	1.00	800
	Structural Backfill	13	CY	40	533	1.00	533
	ARCHITECTURAL / STRUCTURAL						
	Headworks - Concrete	188	CY	800	150,400	1.00	150,400
	Headworks Building	3,200	SF	150	480,000	1.00	480,000
	Misc. Metals, Wood & Plastics, Finishes	1	LS	48,713	48,713	1.00	48,713
	PROCESS / MECHANICAL						
	Screen, Compactor, Washer	1	EA	190,821	190,821	1.00	190,821
	Stainless Steel Gates	4	EA	15,450	61,800	1.00	61,800
	Misc. Mechanical (15% of equip)	0.15	%	252,621	37,893	1.00	37,893
	HVAC / PLUMBING / FIRE PROTECTION						
	Headworks Building	3,200	SF	39	124,420	1.00	124,420
	ELECTRICAL / INSTRUMENTATION						
	Headworks Building	3,200	SF	32	103,683	1.00	103,683
	Misc. Electrical (20% of equip)	0.20	%	252,621	50,524	1.00	50,524
	Misc. I&C (15% of equip)	0.15	%	252,621	37,893	1.00	37,893
					SUBTOTAL	$	1,287,481
3	GRIT REMOVAL						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	Grit Chamber - Concrete	94	CY	800	75,200	1.00	75,200
	Misc. Metals, Wood & Plastics, Finishes,	1	LS	49,763	49,763	1.00	49,763
	PROCESS / MECHANICAL						
	Vortex Grit System	1	EA	242,486	242,486	1.00	242,486
	Misc. Mechanical (15% of equip)	0.15	%	242,486	36,373	1.00	36,373
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	242,486	48,497	1.00	48,497
	Misc. I&C (15% of equip)	0.15	%	242,486	36,373	1.00	36,373
					SUBTOTAL	$	488,692
4	SPLITTER BOX						
	CIVIL / SITE WORK						
	Excavation (soil)	3,565	CY	15	53,477	1.00	53,477
	Backfill (soil)	2,315	CY	20	46,300	1.00	46,300
	Structural Backfill	93	CY	40	3,704	1.00	3,704

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	ARCHITECTURAL / STRUCTURAL						
	Splitter Box - Concrete	200	CY	800	160,000	1.00	160,000
	Misc. Metals	2	LS	15,902	31,804	1.00	31,804
	Misc. FRP Weirs	80	LF	90	7,216	1.00	7,216
	PROCESS / MECHANICAL						
	Stainless Steel Gates	4	EA	8,589	34,356	1.00	34,356
	Misc. Mechanical (15% of equip)	0.15	%	34,356	5,153	1.00	5,153
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	34,356	6,871	1.00	6,871
	Misc. I&C (15% of equip)	0.15	%	34,356	5,153	1.00	5,153
						SUBTOTAL	*$ 354,035*
5	**PRIMARY CLARIFICATION**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	*$ -*
6	**AERATION SYSTEM**						
	CIVIL / SITE WORK						
	Excavation (soil)	108,775	CY	15	1,631,619	1.00	1,631,619
	Backfill (soil)	19,790	CY	20	395,795	1.00	395,795
	Structural Backfill	8,475	CY	40	338,990	1.00	338,990
	ARCHITECTURAL / STRUCTURAL						
	Aeration Basins - Concrete	5,120	CY	600	3,071,978	1.00	3,071,978
	PROCESS / MECHANICAL						
	Submersible Mixers	4	EA	29,624	118,496	1.00	118,496
	MLR Pumps	2	EA	51,470	102,940	1.00	102,940
	Fine Bubble Diffuser System	2	LS	271,988	543,977	1.00	543,977
	Misc. Mechanical (15% of equip)	0.15	LS	765,413	114,812	1.00	114,812
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	765,413	153,083	1.00	153,083
	Misc. I&C (15% of equip)	0.15	%	765,413	114,812	1.00	114,812
						SUBTOTAL	*$ 6,586,502*
7	**BLOWER BUILDING**						
	CIVIL / SITE WORK						
	Excavation (soil)	31	CY	15	467	1.00	467
	Structural Backfill	8	CY	40	311	1.00	311
	ARCHITECTURAL / STRUCTURAL						
	Blower Building	1,200	SF	150	180,000	1.00	180,000
	PROCESS / MECHANICAL						
	Multi-Stage Cent. Blowers	3	EA	388,663	1,165,989	1.00	1,165,989
	Misc. Mechanical (15% of equip)	0.15	%	1,165,989	174,898	1.00	174,898

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project: Prescott Airport and Sundog WWTPs Facilities Master Plan
Job #: 8286A.00
Location: Prescott, AZ
Zip Code: 86301

Updated: June 17, 2010
Estimator: CL/CDM
Project Status: Planning
ENR CCI at Time of Estimate: 8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
	HVAC / PLUMBING / FIRE PROTECTION						
	Blower Building	1,200	SF	39	46,658	1.00	46,658
	ELECTRICAL / INSTRUMENTATION						
	Blower Building	1,200	SF	32	38,881	1.00	38,881
	Misc. Electrical (20% of equip)	0.20	%	1,165,989	233,198	1.00	233,198
	Misc. I&C (15% of equip)	0.15	%	1,165,989	174,898	1.00	174,898
						SUBTOTAL	*$ 2,015,301*
8	**SECONDARY CLARIFICATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	18,727	CY	15	280,898	1.00	280,898
	Backfill (soil)	5,926	CY	20	118,528	1.00	118,528
	Structural Backfill	1,164	CY	40	46,546	1.00	46,546
	ARCHITECTURAL / STRUCTURAL						
	Secondary Clarifiers - Concrete	2,050	CY	800	1,640,000	1.00	1,640,000
	Misc. FRP Baffles and Weirs	2	EA	25,000	50,000	1.00	50,000
	PROCESS / MECHANICAL						
	Clarifier Mechanisms	2	EA	430,000	860,000	1.00	860,000
	Misc. Mechanical (15% of equip)	0.15	%	860,000	129,000	1.00	129,000
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	860,000	172,000	1.00	172,000
	Misc. I&C (15% of equip)	0.15	%	860,000	129,000	1.00	129,000
						SUBTOTAL	*$ 3,425,971*
9	**RAS WAS PUMP STATION**						
	CIVIL / SITE WORK						
	Excavation (soil)	1,783	CY	15	26,738	1.00	26,738
	Backfill (soil)	1,158	CY	20	23,150	1.00	23,150
	Structural Backfill	46	CY	40	1,852	1.00	1,852
	ARCHITECTURAL / STRUCTURAL						
	RAS P. S. - Slab/Footing	35	CY	580	20,300	1.00	20,300
	RAS P. S. - Walls	116	CY	710	82,360	1.00	82,360
	RAS P. S. - Elevated Slab	35	CY	840	29,169	1.00	29,169
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	RAS Pumps	2	EA	40,740	81,480	1.00	81,480
	WAS Pumps	2	EA	11,940	23,880	1.00	23,880
	Scum Pumps	2	EA	7,000	14,000	1.00	14,000
	Misc. Mechanical (15% of equip)	0.15	LS	119,360	17,904	1.00	17,904
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	119,360	23,872	1.00	23,872
	Misc. I&C (15% of equip)	0.15	%	119,360	17,904	1.00	17,904
						SUBTOTAL	*$ 377,609*

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
10	**TERTIARY FILTRATION**						
	CIVIL / SITE WORK						
	Excavation and backfill	1	LS	160,221	160,221	1.00	160,221
	ARCHITECTURAL / STRUCTURAL						
	Filter basins and channels - walls	213	CY	830	177,159	1.00	177,159
	Filter basins and channels - slabs	153	CY	520	79,733	1.00	79,733
	Misc - Metals	1	LS	116,277	116,277	1.00	116,277
	PROCESS / MECHANICAL						
	Disk Filters Equipment	1	LS	727,501	727,501	1.00	727,501
	Chemical feed	1	LS	82,056	82,056	1.00	82,056
	Filter Inlet gates	3	EA	8,002	24,006	1.00	24,006
	Channel gates	3	EA	15,450	46,350	1.00	46,350
	Effluent weir gate	1	EA	16,450	16,450	1.00	16,450
	Sump pump	1	EA	18,616	18,616	1.00	18,616
	Misc. Mechanical (15% of equip)	0.15	%	914,979	137,247	1.00	137,247
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	914,979	182,996	1.00	182,996
	Misc. I&C (15% of equip)	0.15	%	914,979	137,247	1.00	137,247
						SUBTOTAL *$*	***1,905,859***
11	**DISINFECTION**						
	CIVIL / SITE WORK						
	Excavation (soil)	162	CY	15	2,432	1.00	2,432
	Backfill (soil)	66	CY	20	1,322	1.00	1,322
	Structural Backfill	27	CY	40	1,067	1.00	1,067
	ARCHITECTURAL / STRUCTURAL						
	UV Channels - Slab/Footing	13	CY	580	7,734	1.00	7,734
	UV Channels - Walls	53	CY	710	37,743	1.00	37,743
	PROCESS / MECHANICAL						
	UV Equipment	4	LS	336,914	1,347,656	1.00	1,347,656
	Misc. Mechanical (15% of equip)	0.15	LS	1,347,656	202,148	1.00	202,148
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	1,347,656	269,531	1.00	269,531
	Misc. I&C (15% of equip)	0.15	%	1,347,656	202,148	1.00	202,148
						SUBTOTAL *$*	***2,071,782***

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CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
12	**EFFLUENT PUMPING**						
	CIVIL / SITE WORK						
	Excavation (soil)	2,621	CY	15	39,309	1.00	39,309
	Backfill (soil)	1,621	CY	20	32,410	1.00	32,410
	Structural Backfill	74	CY	40	2,963	1.00	2,963
	ARCHITECTURAL / STRUCTURAL						
	Concrete - Pump Station	160	CY	600	96,000	1.00	96,000
	Misc - Metals	1	LS	15,000	15,000	1.00	15,000
	PROCESS / MECHANICAL						
	Effluent Pumps	2	EA	32,342	64,685	1.00	64,685
	Misc. Mechanical (15% of equip)	0.15	LS	64,685	9,703	1.00	9,703
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	64,685	12,937	1.00	12,937
	Misc. I&C (15% of equip)	0.15	%	64,685	9,703	1.00	9,703
						SUBTOTAL	*$ 282,709*
13	**SOLIDS HANDLING**						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Dewatering Centrifuge Package	1	EA	348,445	348,445	1.00	348,445
	Misc. Mechanical (15% of equip)	0.15	%	348,445	52,267	1.00	52,267
	HVAC / PLUMBING / FIRE PROTECTION						
	None	--	--	--	--	--	0
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	348,445	69,689	1.00	69,689
	Misc. I&C (15% of equip)	0.15	%	348,445	52,267	1.00	52,267
						SUBTOTAL	*$ 522,668*
14	**ANAEROBIC DIGESTION**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	*$ -*
15	**ADMINISTRATION BUILDING**						
	CIVIL / ARCHITECTURAL / STRUCTURAL / PROCESS / ELECTRICAL & INSTRUMENTATION						
	None	--	--	--	--	--	0
						SUBTOTAL	*$ -*

Carollo

CENTRALIZED TREATMENT ALTERNATIVE (MLE) - PHASE 1 (3.75 MGD)
PROJECT SUMMARY

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	June 17, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, AZ	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	8677

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Install. Factor	Total Cost
16	ODOR CONTROL						
	CIVIL / SITE WORK						
	None	--	--	--	--	--	0
	ARCHITECTURAL / STRUCTURAL						
	None	--	--	--	--	--	0
	PROCESS / MECHANICAL						
	Primary Odor Control System (Headworks,	1	LS	235,092	235,092	1.00	235,092
	Misc. Mechanical (15% of equip)	0.15	LS	235,092	35,264	1.00	35,264
	ELECTRICAL / INSTRUMENTATION						
	Misc. Electrical (20% of equip)	0.20	%	235,092	47,018	1.00	47,018
	Misc. I&C (15% of equip)	0.15	%	235,092	35,264	1.00	35,264
						SUBTOTAL	***$ 352,638***
17	MISCELLANEOUS ONSITE						
	CIVIL / SITE WORK						
	Civil/Sitework	0.12	%	19,671,247	2,360,550	1.00	2,360,550
						SUBTOTAL	***$ 2,360,550***

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

OPERATIONS AND MAINTENANCE COSTS ESTIMATE

PHASE 1 (3.75 MGD)

CONVENTIONAL (MLE) PROCESS TREATMENT ALTERNATIVE

carollo

AIRPORT WATER RECLAMATION FACILITY
CENTRALIZED TREATMENT PROCESS (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - 3.75 MGD WITHOUT DIGESTION

Project:	Prescott Airport and Sundog WWTPs Facilities Master Plan	Updated:	April 27, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	DESCRIPTION	Total Cost
1	ANNUAL POWER COSTS	$646,000
2	ANNUAL CHEMICAL COSTS	$163,000
3	ANNUAL LABOR COSTS	$540,000
4	ANNUAL MISCELLANEOUS COSTS	$438,000
	ESTIMATED ANNUAL O&M TOTAL	**$1,787,000**
	PRESENT WORTH FACTOR	***13.74***
	O&M PRESENT WORTH COST TOTAL	**$24,547,820**

NOTES

1. Present worth factor annual interest rate = 6%
2. Present worth factor annual inflation rate = 2%
3. Present worth factor planning period (yrs) = 20

Carollo

AIRPORT WATER RECLAMATION FACILITY
CENTRALIZED TREATMENT PROCESS (MLE) - OPERATION & MAINTENANCE COSTS
PROJECT SUMMARY - 3.75 MGD WITHOUT DIGESTION

Project:	Prescott Airport and Sundog WRF Technology Assessments	Updated:	April 27, 2010
Job #:	8286A.00	Estimator:	CL/CDM
Location:	Prescott, Az	Project Status:	Planning
Zip Code:	86301	ENR CCI at Time of Estimate:	*8677*

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**ANNUAL POWER COSTS**					
	Headworks	554,332	kW-hr	0.10	55,400	$55,400
	Primary Treatment	0	kW-hr	0.10	-	$0
	Secondary Treatment	3,256,284	kW-hr	0.10	325,600	$325,600
	Tertiary Filtration	16,484	kW-hr	0.10	1,600	$1,600
	UV Disinfection System	709,355	kW-hr	0.10	70,900	$70,900
	Effluent Pumping System	147,926	kW-hr	0.10	14,800	$14,800
	Sludge Thickening	0	kW-hr	0.10	-	$0
	Sludge Digestion	0	kW-hr	0.10	-	$0
	Sludge Dewatering	616,322	kW-hr	0.10	61,600	$61,600
	Solids Handling Building	297,139	kW-hr	0.10	29,700	$29,700
	Odor Control	856,809	kW-hr	0.10	85,700	$85,700
					ANNUAL POWER COST SUBTOTAL	***$645,300***
2	**ANNUAL CHEMICAL COSTS**					
	Disk Filters	1	LS	-	2,000	$2,000
	Chemicals (Caustic, Sodium Hypochlorite, Ferrous Chloride)	1	LS	-	116,800	$116,800
	Emulsion Polymer, Active	17,537	lb	1.85	32,400	$32,400
	Hydrochloric Acid	1	LS	--	3,900	$3,900
	Diesel Fuel	1	LS	--	5,900	$5,900
	Oils and Lubricants	1	LS	--	2,000	$2,000
					ANNUAL CHEMICAL COST SUBTOTAL	***$163,000***
3	**ANNUAL LABOR COSTS (including 32% for benefits)**					
	Operators	5	staff	60,000	300,000	$300,000
	Mechanical	1	staff	65,000	65,000	$65,000
	Supervisor	1	staff	75,000	75,000	$75,000
	Electrical/Instrumentation	1	staff	65,000	65,000	$65,000
	Administration	1	staff	35,000	35,000	$35,000
					ANNUAL LABOR SUBTOTAL	***$540,000***
4	**ANNUAL MISCELLANEOUS COSTS**					
	Disk Filters - Maintenance	1	LS	-	5,400	$5,400
	Annual UV Lamp Replacement Cost	1	LS	-	64,000	$64,000
	Off-Site Sludge Disposal	5,518	wet ton	15.00	82,800	$82,800
	Off-Site Screenings/Grit Disposal	1	LS	--	3,000	$3,000
	General Parts and Supplies	1	LS	--	15,000	$15,000
	Communication Charges	12	months	1,300	15,600	$15,600
	Potable Water Charges	12	months	600	7,200	$7,200
	Major Process Parts Replacement	1	LS	--	80,000	$80,000
	Centrifuge Maintenance Services Contract	1	LS	--	40,000	$40,000
	Generator Maintenance Services Contract	1	LS	--	75,000	$75,000
	Miscellaneous	1	LS	--	50,000	$50,000
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$438,000***

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 7
Tertiary Filtration Evaluation

Final

In Association with

Project No. 164890

3133 E. Camelback Rd • Suite 210 • PHOENIX, ARIZONA 85016 • (602) 381-4400 • FAX (602) 381-4440

City of Prescott

TECHNICAL MEMORANDUM
NO. 7
TERTIARY FILTRATION EVALUATION

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ES7 TM 7 – TERTIARY FILTRATION EVALUATION

ES7.1 Introduction

The purpose of this technical memorandum is to evaluate alternative tertiary filtration technologies for the Sundog WWTP and Airport WRF.

ES7.2 Background

The last major expansion of the Sundog WWTP liquid treatment process, including filters, was constructed in 1990. The existing tertiary filtration process consists of two traveling bridge filters. The filters have historically met all discharge permit limits, without significant operator complaints. The filters have recently experienced failures in the porous plates. The existing filters need to be rebuilt or replaced.

The most recent expansion of the Airport WRF occurred in 1998 and included the addition of one traveling bridge filter. Plant staff have reported ongoing plugging issues with the porous plate in the existing unit. Also, there is a lack of redundancy and the filter cannot be taken off-line and cleaned thoroughly without losing the ability to filter secondary effluent prior to UV disinfection.

ES7.3 Hydraulic Design Criteria

Projected annual average wastewater flows tributary to the Sundog WWTP and Airport WRF are presented in Table ES7.1

Table ES7.1 Projected Wastewater Flows

	Sundog WWTP			Airport WWTP		
	2010	**2015**	**Buildout**	**2010**	**2015**	**Buildout**
Master Plan AAD	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	4.9 mgd
West Area AAD	---	---	---	0	0	2.2 mgd
Granite Creek AAD	---	---	---	TBD	TBD	2.0 mgd
Total	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	9.1 mgd

The Sundog WWTP collection system experiences significant wet weather inflow and infiltration, as illustrated in Figure ES7.1.

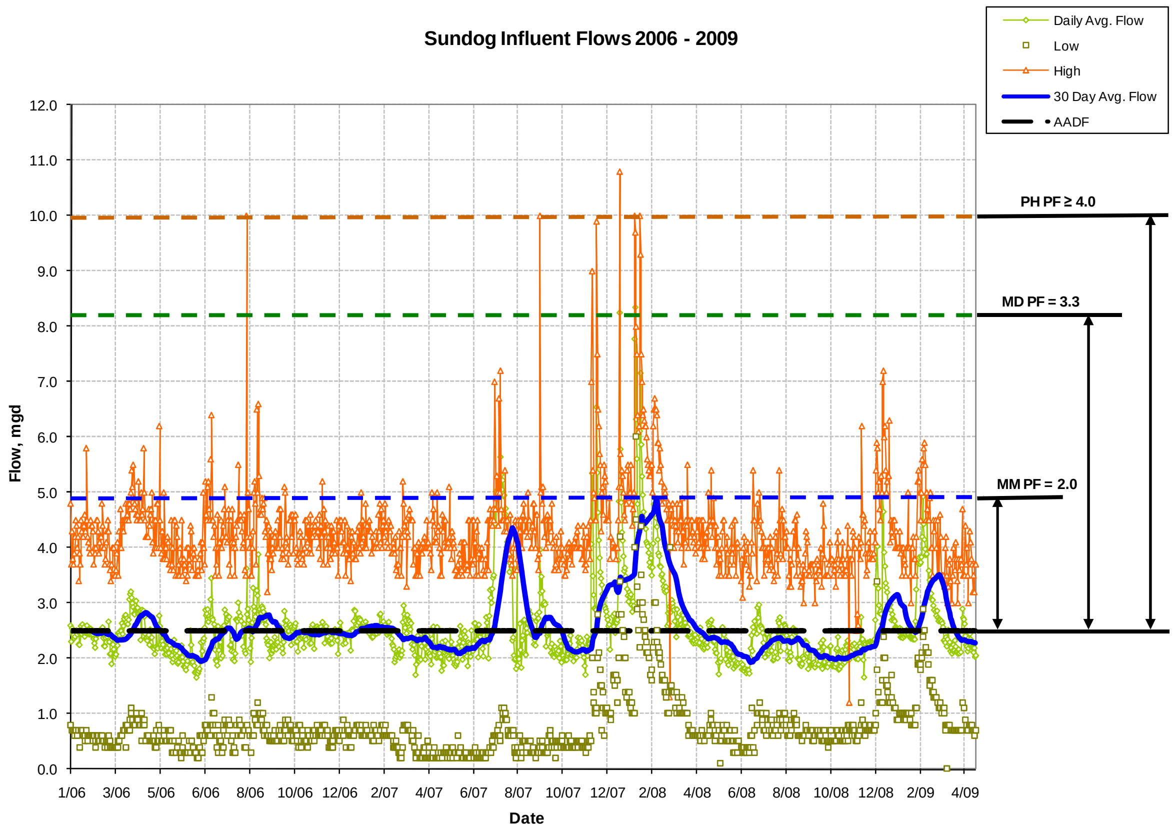


Figure ES7.1 Monthly Sundog WWTP Floes 2006 - 2009

Based on this data it is recommended to design the Sundog WWTP filters for a maximum month hydraulic flow capacity of 2.0 times average annual design capacity and rely on flow equalization to store excess wet weather flows above maximum month flow. Therefore, build out hydraulic capacity of the Sundog WWTP filters should be 10.6 mgd, with one unit out of service.

The impact of wet weather infiltration and inflow is not as great at the Airport WWTP, as shown in Figure ES7.2.

A hydraulic design capacity of 2.0 times average annual flow or 18.2 mgd for the build out condition is recommended for the Airport WWTP filters. Flow equalization is recommended to store and equalize flows is excess of peak day flow.

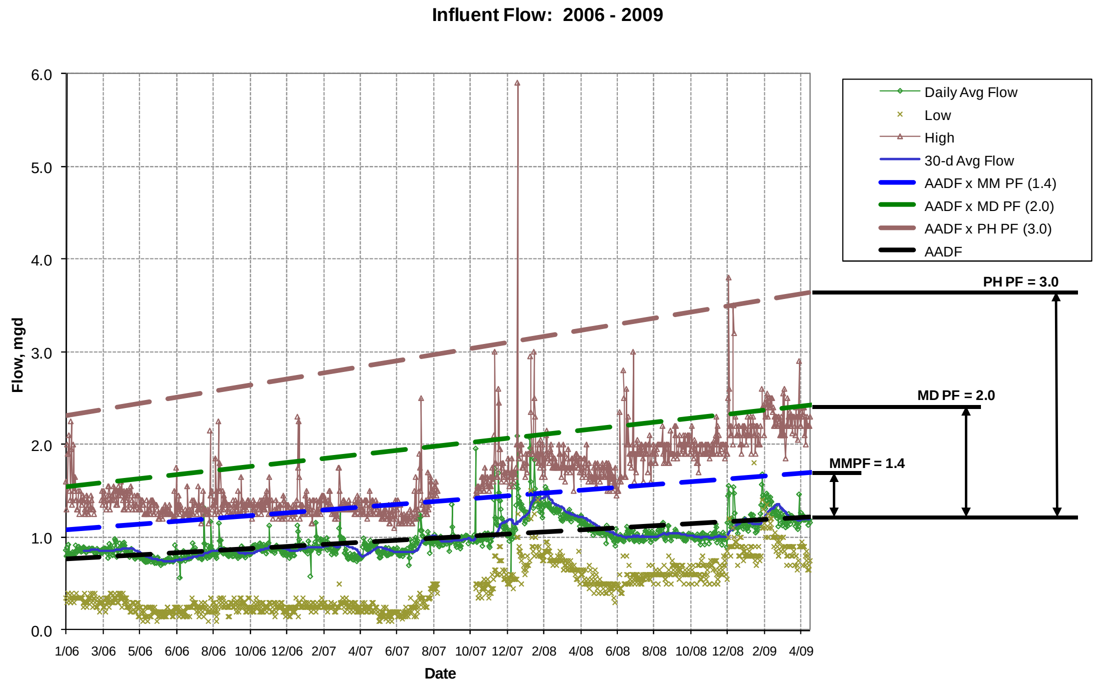


Figure ES7.2 Monthly Airport WWTP Floe 2006 - 2009

ES7.4 Required Reclaimed Water Quality

The current project will evaluate tertiary filtration technologies that are capable of producing Class A+ effluent. The current water quality standards for Class A+ Reclaimed Water are shown in Table ES7.2.

Table ES7.2 Class A+ Reclaimed Water Quality Standards	
Parameter	**Treatment Standard**
Turbidity, NTU	
• Average	2
• Single sample max	5
Fecal Coliform, cfu/100mL	
• 4 of last 7 samples	Non-detect
• Single sample max	23
APP	
• BADCT	THM control

Historical filter performance at both the Sundog WWTP and Airport WRF has met Class A+ average turbidity of $\leq$2 NTU, except for periods of extreme wet weather flows. However, the Sundog WWTP filters have recently experienced structural failure of the media support porous plate and are out of service.

ES7.5 Filtration Alternatives

The following filtration alternatives were considered:

- Existing Traveling Bridge Filter Retrofit
  - ✓ Conventional underdrain replacement – Infilco (ABF)
  - ✓ Pipe underdrain replacement – Siemens (Gravisand)
- Disk Filter Technology
- Cloth Media Filters – Aqua Aerobics (AquaDiamond)
- Compressible Media Filter – Schreiber (Fuzzy Filter)
- Upflow Continuous Backwash Filters
- Conventional Deep Bed Filtration
- Microfiltration
  - ✓ Submerged – General Electric
  - ✓ Pressure Vessels – Siemens, Pall

ES7.6 Comparison of Tertiary Filtration Technologies

Hydraulic loading criteria varies for each of the filtration technologies. The resulting basis of design for each technology for the Sundog WWTP and Airport WRF are presented in Table ES7.3 and Table ES7.4.

Table ES7.3 Sundog WWTP Filtration Basis of Design Criteria

Filter Technology	Total Surface Area, ft^2		No. Units Required		New Concrete Basin or Structure	Pump Station Required
	Average	Peak (Max Month)	Duty	Standby		
Traveling Bridge Filters	**3,120**	**3,120**	2	1	yes	no
Disk Filters	**1,764**	**1,764**	2	1	no	no
Cloth Media Filters	**2,600**	**2,600**	1	1	no	no
Compressible Media Filters	174	**253**	4	1	yes	yes
Upflow Continuous Backwash Filters	1,146	**1,526**	27	1	yes	yes
Conventional Filters	**2,400**	1,964	4	1	yes	yes
Microfiltration (2)	132,500	**265,000**	11	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based on a standard 50 module rack.

Table ES7.4 Airport WWTP Filtration Basis of Design Criteria

Filter Technology	Total Surface Area, ft^2		No. Units Required		New Concrete Basin or Structure	Pump Station Required
	Average	Peak (Peak Day)	Duty	Standby		
Traveling Bridge Filters	**4,025**	**4,025**	6	1	yes	no
Disk Filters	**2,750**	**2,750**	4	1	yes	no
Cloth Media Filters	**4,160**	**4,160**	1	1	yes	no
Compressible Media Filters	294	**400**	7	1	yes	yes
Upflow Continuous Backwash Filters	1,953	**2,582**	47	1	yes	yes
Conventional Filters	**4,200**	3,600	6	1	yes	yes
Microfiltration (2)	227,500	**455,000**	19	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based upon a standard 50 module rack.

Tertiary filtration alternatives were compared based on economic and non-economic criteria.

A capital, operating and life cycle present worth cost comparison of filtration technologies for the Sundog WWTP and Airport WRF are presented on Table ES7.5 and Table ES7.6 respectively.

Table ES7.5 Sundog WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Compressible Media	Upflow Filters	Conventional	Microfiltration
Capital Cost	$1,950,000	$2,166,000	$2,836,000	$2,970,000	$3,039,000	$4,740,000	$13,487,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance (parts only)	$6,200	$8,400	$4,100	$800	$1,400	$10,300	$51,000
Power ($0.10/kWH)	$8,100	$2,400	$5,900	$16,700	$16,700	$16,400	$52,600
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$114,000
Total Life Cycle Cost w/o UV	**$2,300,000**	**$2,500,000**	**$3,200,000**	**$3,400,000**	**$3,500,000**	**$5,300,000**	**$16,600,000**
UV Power	$63,100	$63,100	$63,100	$63,100	$63,100	$63,100	$19,300
Total Life Cycle Cost w/ UV	**$3,000,000**	**$3,200,000**	**$3,900,000**	**$4,100,000**	**$4,200,000**	**$6,000,000**	**$16,800,000**

Table ES7.6 Airport WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Fuzzy Filter	Upflow Filters	Deep Bed	Microfiltration
Capital Cost	$4,838,000	$3,818,000	$4,640,000	$4,541,000	$4,812,000	$11,676,000	$22,423,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance	$14,000	$13,000	$4,000	$5,000	$2,000	$14,000	$42,000
Power	$19,000	$4,000	$6,000	$17,000	$16,000	$16,000	$43,000
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$93,000
Total Life Cycle Cost w/o UV	**$5,400,000**	**$4,200,000**	**$5,000,000**	**$5,000,000**	**$5,200,000**	**$12,200,000**	**$25,100,000**
UV Power	$110,000	$110,000	$110,000	$110,000	$110,000	$110,000	$39,000
Total Life Cycle Cost w/ UV	$6,700,000	$5,500,000	$6,200,000	$6,300,000	$6,500,000	$13,500,000	$25,500,000

Table ES7.7 shows a relative comparison of the filtration technologies based on a score of 1 through 10 (higher value means more desirable). A multiplier was also applied to each of the non-economic factors to properly weigh those factors most important to the City.

ES7.7 Recommendations

The recommended tertiary filtration alternative for implementation at the Sundog and Airport WWTPs is disk filters. Disk filters provide a good mixture of low cost, reliable performance and low maintenance

Table ES7.7 Non-Economic Factor Comparison											
	Effluent Quality		**Proven Technology**		**Operational Complexity**		**Compatibility with Future AOPs**		**Footprint**		**Total Overall Score**
Weighting Factor	**x 5**		**x 4**		**x 3**		**x2**		**x2**		
Treatment Technology	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	
Traveling Bridge Filter	7	35	9	36	6	18	5	10	4	8	107
Disk Filters	7	35	9	36	8	24	5	10	8	16	121
Cloth Media Filters	7	35	7	28	7	21	5	10	6	12	106
Compressible Media Filters	6	30	4	16	5	15	3	6	8	16	83
Upflow Filters	5	25	8	32	6	18	3	6	6	12	93
Conventional Filters	7	35	9	36	3	9	5	10	3	6	96
Microfiltration	10	50	7	28	4	12	10	20	4	8	118
Comparison of non-economic factors where 10 = best and 1 = worst											

1.0 SCOPE

The purpose of this technical memorandum is to evaluate alternative tertiary filtration technologies for the Sundog WWTP and Airport WRF. Several filtration technologies have been identified for the evaluation, including (1) reburish/retrofit/expand the existing traveling bridge filters, (2) disk filters, (3) cloth filters, (4) compressible media filters, (5) upflow continuous backwash filters, (6) conventional deep bed filters, and (7) microfiltration. There is an urgent need for replacement of the filters at the Sundog WWTP, therefore, this filtration evaluation is being accelerated within the project schedule. This document describes the various filtration technologies with advantages and disadvantages, summarizes the sizing criteria for each technology, and presents an economic and non-economic comparison of the alternatives.

2.0 BACKGROUND

2.1 Sundog WWTP

The Sundog WWTP is located approximately 2 miles northeast of the center of the City of Prescott (City) and currently receives the majority of the City's wastewater flow. The last major expansion of the liquid treatment process, including filters, was constructed in 1988. The existing tertiary filtration process consists of two traveling bridge filters. The filters have historically met all discharge permit limits, without significant operator complaints.

The filters have recently experienced failures in the porous plates as shown in the photograph in Figure 2.1. The porous plate and underdrains need to be replaced or new filters constructed. The filters were designed to handle peak wet weather flows, however no redundancy was provided in the 1988 project. The evaluation of tertiary filtration technologies at the Sundog WWTP will take into account the current filter issues and also add redundancy to the filtration process.

Figure 2.1: Sundog Filter Porous Plate Failure

2.2 Airport WWTP

The Airport WWTP is located adjacent to the Prescott Municipal Airport north of the center of the City. The City's infiltration basins are also located in the area. The most recent expansion of the plant occurred in 1998 and included the addition of tertiary filtration. Two traveling bridge filters were originally designed for the project, however due to budget constraints only one of the filters was constructed.

The existing filter will handle approximately 1.6 mgd if loaded hydraulically to the standard design criteria of approximately 2-3 gpm/sf. Plant staff have reported ongoing plugging issues with the porous plate in the existing unit. Also, there is a lack of redundancy and the filter cannot be taken off-line and cleaned thoroughly without losing the ability to filter secondary effluent prior to UV disinfection. The evaluation of the tertiary filtration technologies will address this redundancy issue at the plant.

3.0 HYDRAULIC DESIGN CRITERIA

Current and projected wastewater average annual design daily (AAD) flows tributary to the Sundog and Airport WWTPs are shown below in Table 3.1.

Subsequent to the Master Plan it was decided to include planning for the area west of the airport known as the West Airport Area and the area east of Granite Creek and north of Highway 89A. These flows are tributary to the Airport WWTP and included in Table 3.1.

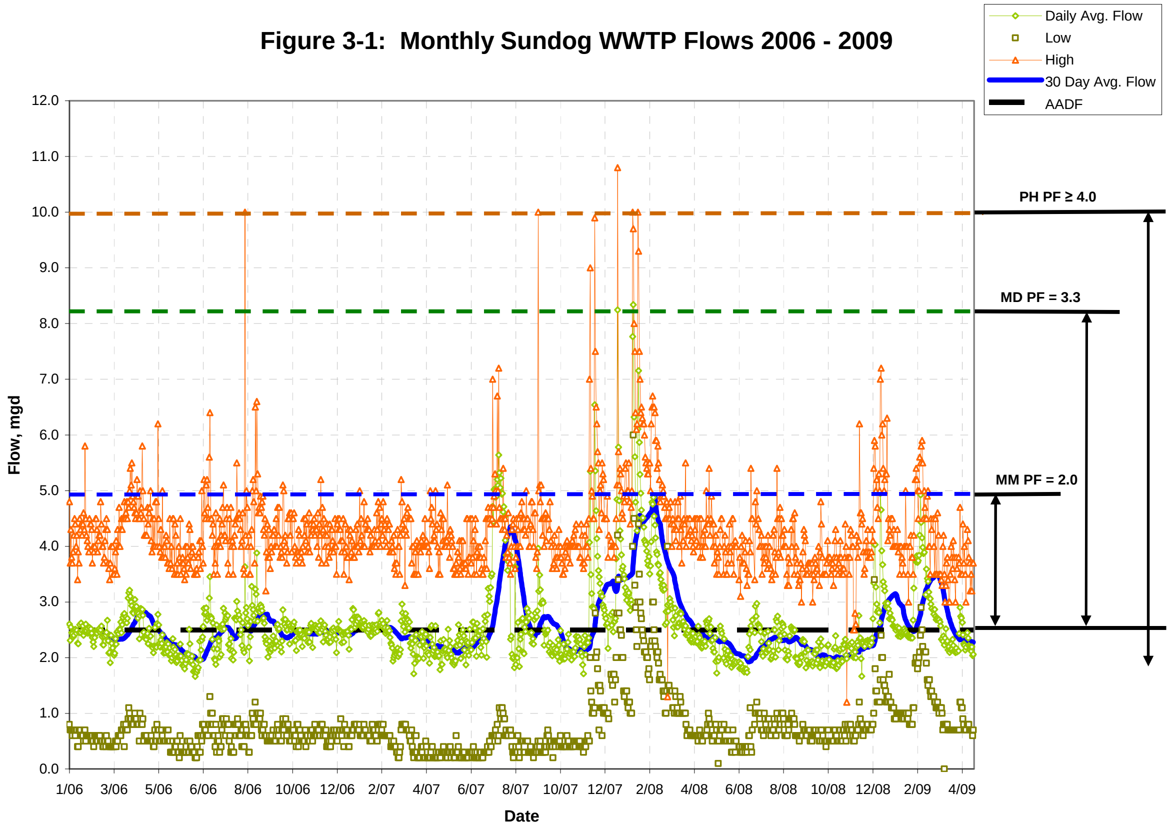
Table 3.1 Projected Wastewater Flows

	Sundog WWTP			Airport WWTP		
	2010	**2015**	**Buildout**	**2010**	**2015**	**Buildout**
Master Plan AAD	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	4.9 mgd
West Area AAD	---	---	---	0	0	2.2 mgd
Granite Creek AAD	---	---	---	TBD	TBD	2.0 mgd
Total	2.5 mgd	2.8 mgd	5.3 mgd	1.1 mgd	1.3 mgd	9.1 mgd

3.1 Peak Flows and Hydraulic Design Capacity for the Sundog WWTP

The collection system tributary to the Sundog WWTP experiences significant wet weather inflow and infiltration, as illustrated in Figure 3.1. For the period 2006 through 2009, the average annual dry (AAD) weather flow was 2.5 mgd. Maximum month (MM) wet weather flow occurred in January/February 2008 at 5.0 mgd giving a MM/AAD peaking factor of 2.0. Worst case wet weather flows occurred on January 27 through January 29. During those days influent flow exceeded the maximum month flow for an extended period. Based on this data it is recommended to design the Sundog WWTP filters for a maximum month hydraulic flow capacity of 2.0 times average annual design capacity and rely on flow equalization to store excess wet weather flows above maximum month flow. Therefore, build out hydraulic capacity of the Sundog WWTP filters will be 10.6 mgd, with one unit our of service.

Figure 3-1: Monthly Sundog WWTP Flows 2006 - 2009



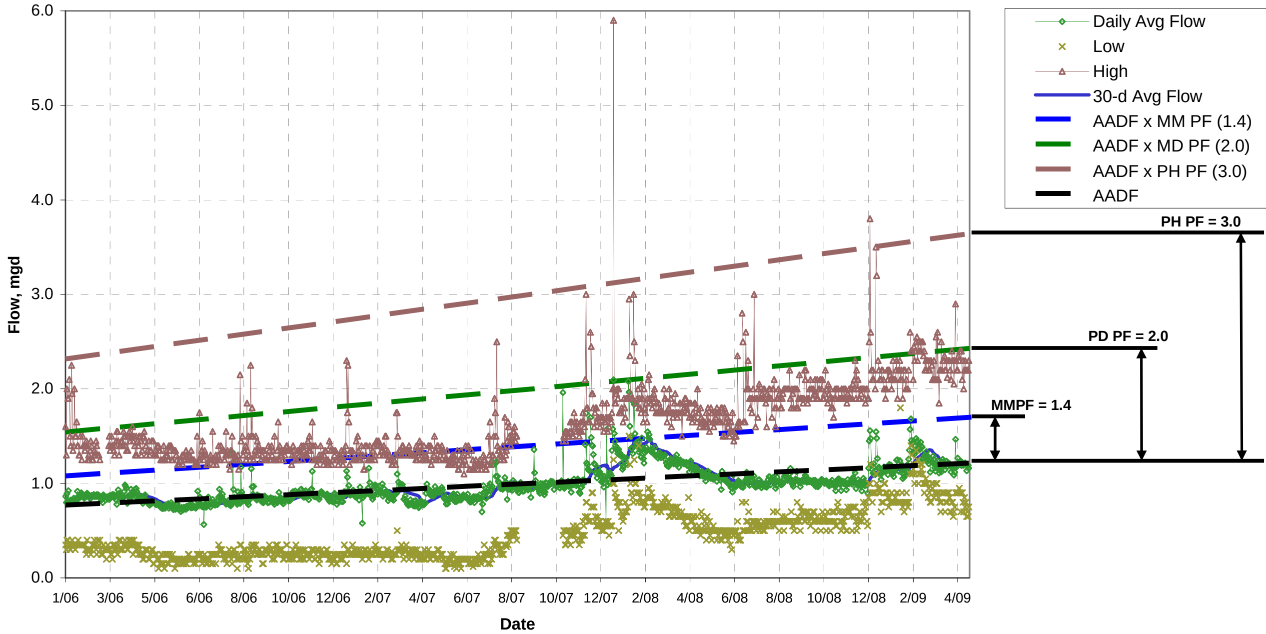
Note: The Sundog WWTP influent flow meter does not read above 10.0 mgd, on several occasions the influent flow meter pegged out at 10 mgd. The true maximum hour peaking factor is unknown, but is likely 4.5 or higher.

3.2 Peak Flows and Hydraulic Design Capacity for the Airport WWTP

The impact of wet weather infiltration and inflow is not as great at the Airport WWTP, as shown in Figure 3.2. A peaking factor of 2.0 times average annual flow (same factor as recommended for the Sundog WWTP) would be adequate to accommodate peak day flow.

A hydraulic design capacity of 2.0 times average annual flow or 18.2 mgd for the build out condition is recommended for the Airport WWTP filters. Flow equalization is recommended to store and equalize flows is excess of peak day flow.

Figure 3-2: Monthly Airport WWTP Flow: 2006 - 2009



4.0 REQUIRED RECLAIMED WATER QUALITY

The Sundog and Airport WWTPs were both designed and permitted to produce Class B+ effluent, and the Draft APP that is currently under negotiation with ADEQ is structured for Class B+ effluent. Given the potential for future water quality standards in the APP, the current project will evaluate tertiary filtration technologies that are capable of producing Class A+ effluent. The current water quality standards for Class A+ Reclaimed Water are shown in Table 4.1.

Table 4.1 Class A+ Reclaimed Water Quality Standards

Parameter	Treatment Standard
Turbidity, NTU	
• Average	2
• Single sample max	5
Fecal Coliform, cfu/100mL	
• 4 of last 7 samples	Non-detect
• Single sample max	23
APP	
• BADCT	THM control

Historic performance of the Sundog WWTP and Airport WWTP filters compared with Class A+ performance is shown on Figures 4.1 and 4.2. Existing filter effluent turbidity meets Class A+ requirements. The only exceptions are during high wet weather flow periods. Addition of wet weather flow equalization should help eliminate turbidity exceedances. Only technologies capable of Class A+ performance are included in this evaluation.

Figure 4-1: Sundog WWTP Historic Filter Performance

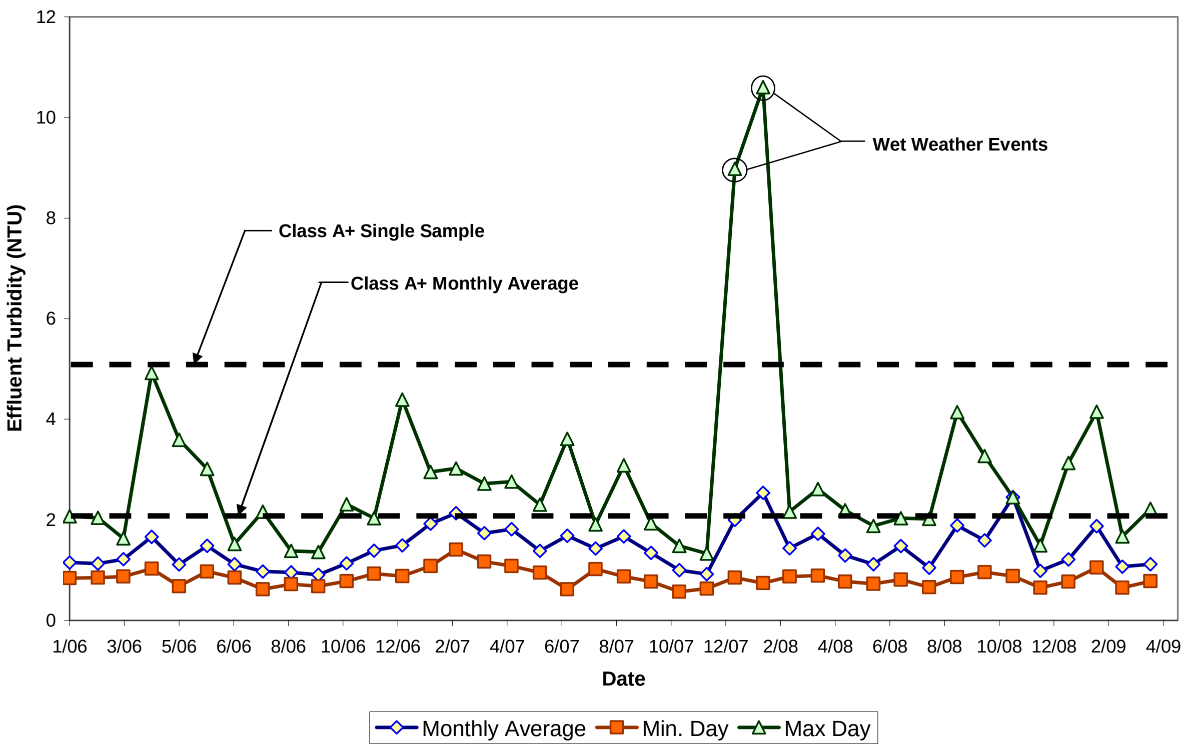
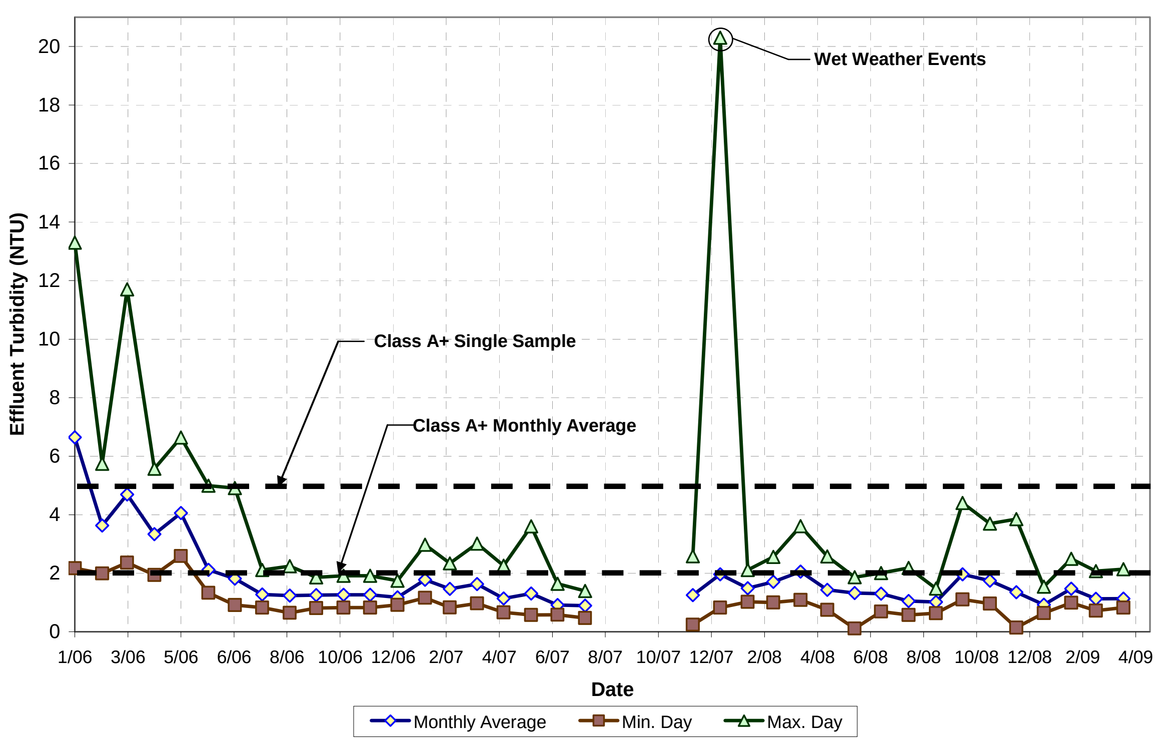


Figure 4-2: Airport WWTP Historic Filter Performance



5.0 FILTRATION ALTERNATIVES

5.1 Existing Traveling Bridge Filter Retrofit

Traveling bridge filters consist of a shallow bed of granular media separated into multiple cells or compartments. These compartments allow a small portion of the filter bed to be backwashed while the rest of the filter remains in service. A dual composition of anthracite and sand, approximately 10 to 12 inches in depth, is typically used as the filter media. A backwash hood is supported by a rail mounted bridge system which travels the length of the filter isolated each cell individually for backwash.

The continuous backwash process significantly reduces the flow rate of backwash water. This eliminates the need for high capacity backwash pumps and spent backwash storage tanks.

Advantages / Disadvantages. The traveling bridge filter technology has the following advantages and disadvantages relative to the other filtration technologies under consideration.

Advantages:

- Proven technology
- Filter remains in service during backwash
- Low backwash rates between 2 to 5 percent of total throughput
- Low headloss through filter

Disadvantages:

- Moderate equipment complexity (moving parts)
- Higher maintenance requirements
- Less effective in handling peak loads
- Large footprint
- Requires periodic super chlorinating to remove bacteria build-up on the porous plate underdrain
- Equipment reliability
- Sporadic vendor support

5.1.1 Conventional Underdrain Replacement – Infilco (ABF)

A conventional traveling bridge filter underdrain assembly consists of porous plates installed over composite U-shaped channels. The porous plates serve to pass filtered process water and retain the filter media within the basin. The filter media is placed over the porous plates and divided into 12-inch segments by cell divider plates. Influent flows down through the filter media and porous plate. The filtered process water is then conveyed out of the filter basin through the U-shaped underdrains.

5.1.2 Pipe Underdrain Replacement – Siemens (Gravisand)

The Siemens Gravisand Filtration system operates similar to a conventional underdrain system, however slotted pipes are substituted for the porous plate and underdrain system. The advantage to this system is the ease of installation, allowing for a quicker and cost effective retrofit of existing facilities.

5.2 Disk Filter Technology

Disk filters are comprised of hollow disk elements with filter media on the exterior. Flow either passes from the inside of the disk to the outside or from the outside to inside. As flow passes through the filter media solids are trapped on the surface. The filters are periodically backwashed to remove the buildup of solids. Two common media types are available, a pile filter media which resembles a shag carpet or a woven polyester fabric.

Disk filters combine a large filtration surface area with higher loading rates than traditional sand filters providing a high ratio of filtration capacity to equipment footprint. These filters are a good choice for retrofit of existing facilities to increase filtration capacity within existing structures.

Advantages / Disadvantages. The disk filter technology has the following advantages and disadvantages relative to the other filtration technologies under consideration.

Advantages:

- Small footprint and use of existing basins
- Low headloss through filter
- Very low backwash water requirements, less than 1% of throughput
- Filter remains in service while backwashed
- Handles peak loadings well

Disadvantages:

- Shorter performance/reliability track record in comparison with traveling bridge filters

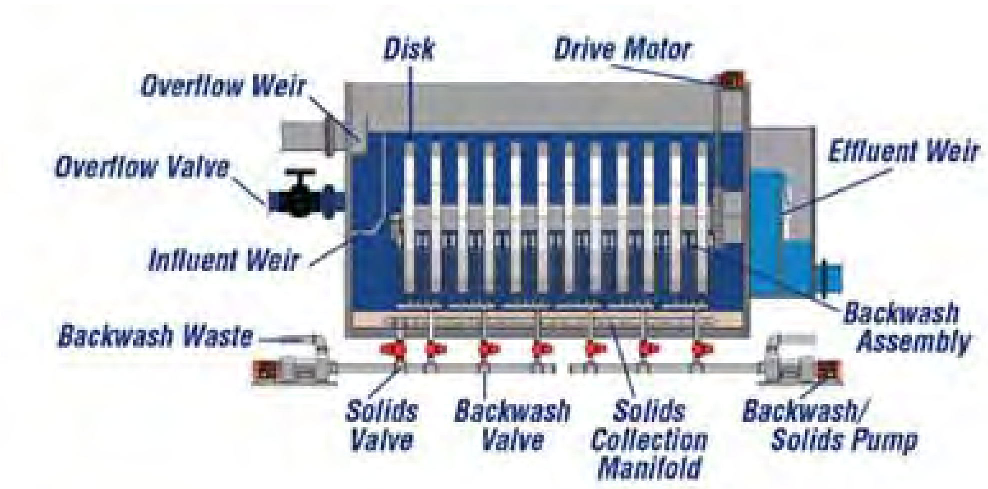
- Cloth media may not be compatible with polymer addition, if required for filter performance optimization
- Slightly lower effluent quality compared with traveling bridges under normal loadings (but meets Class A+)

5.2.1 Outside-In Flow Pattern - Aqua-Aerobics (AquaDisc)

The Aqua-Aerobic AquaDisc cloth media filter uses a PA-13 pile cloth as the filter media. The cloth media is attached to pie-shaped hollow disks mounted vertically on a common effluent tube that conveys filtered process water from the filter basin, with the flow pattern commonly referred to as “outside-in”. The cloth covered disks are stationary and submerged in the filter basin during normal operation. Heavier solids are allowed to settle in the filter basin and periodically pumped from the basin. This reduces the solids load on the membranes and the required frequency of the backwash cycle.

The disks also remain submerged and in operation during a backwash cycle. Suction heads located on each side of the filter disk draw filtered water back through the cloth membrane removing the entrapped particles as the disk rotates at a speed of 1 fps. Figure 5.1 depicts a schematic of the Aqua-Aerobic AquaDisc filter.

Figure 5.1: Aqua-Aerobic AquaDisk Schematic



5.2.2 Inside-Out Flow Pattern - Kruger (Hydrotech Discfilter)

Flow enters the Kruger Hydrotech disk filter through a center drum and then flows through the woven polyester filter disks, which are partially submerged in the filtrate, with a flow pattern commonly referred to as “inside-out”. Solids are retained on the inside of the filter disks. When the water level in the center drum rises to a preset level, a backwash cycle is initiated during which the disks rotate and high pressure spray wash is applied to the outside of the disks. The filtrate serves as the backwash water. The backwash is collected in a separate trough. Figure 5.2 depicts a Kruger Hydrotech 20-disk filter under construction in Flagstaff, Arizona.

Figure 5.2: Kruger Hydrotech Disk Filter under Construction – Flagstaff, Arizona

Table 5.1 summarizes the equipment of each manufacturer.

Table 5.1 Disk Filter Equipment Summary		
Manufacturer	**Aqua-Aerobic**	**Kruger**
Equipment	AquaDisk	Hydrotech Discfilter
Disk Material	PA-13 pile cloth	Woven polyester
Effective (submerged) filter surface area per disk, sf	53.8	39.2
Percent submergence	100 (always submerged)	65 max (varies from 50-65)
Filter drive motor, hp	0.75	1.5
Backwash pump motor, hp	2-2 hp	15
Backwash method	Vacuum	High pressure spray – 110 psi
Backwash quantity	1-2%	1-3 %
Number of US Installations	>500	>100
California DHS Title 22 conditional acceptance	Yes	Yes

5.3 Cloth Media Filters – Aqua Aerobics (AquaDiamond)

The cloth media filter uses a high density cloth membrane as a filter media. The cloth membrane is attached to diamond shaped tubes mounted horizontally that conveys filtered process water from the filter basin. The cloth diamonds are stationary and submerged in the filter basin during normal operation. Heavier solids are allowed to settle in the filter basin and periodically pumped from the basin. This reduces the solids load on the membranes and the required frequency of the backwash cycle.

The diamonds also remain submerged and in operation during a backwash cycle. Suction heads located on each side of the diamond draw filtered water back through the cloth membrane removing entrapped particles. The suction heads are mounted below a traveling bridge mechanism which travels the length of the basin. A high pressure spray backwash cycle is also used approximately once per week to control biological growth on the cloth media.

Advantages / Disadvantages. The cloth media filter technology has the following advantages and disadvantages relative to the other filtration technologies under consideration.

Advantages:

- Small footprint
- Low headloss through filter
- Very low backwash water requirements, less than 1% of throughput
- Filter remains in service while backwashed

Disadvantages:

- Moderate equipment complexity (moving parts)
- Shorter performance/reliability track record in comparison with traveling bridge filters and disc filters
- Cloth media may not be compatible with polymer addition, if required for filter performance optimization
- Proprietary equipment and would be difficult to achieve competitive bidding

5.4 Compressible Media Filter – Schreiber (Fuzzy Filter)

The fuzzy filter uses compressible fiber media set between two plates. The porosity of the filter media can be adjusted by changing the compression level of the media. Fluid flows through the media as opposed to around the media in conventional filters. Significantly higher surface loadings are possible due to the porosity of the media. The depth of the media bed is typically in the range of 24 to 30 inches. During a backwash cycle, the compression plates are opened allowing the media to expand. The direction of flow in the filter is reversed and air is introduces to help scour the media. A typical backwash rate is approximately 10 gpm for 30 minutes.

Advantages / Disadvantages. The fuzzy filter technology has the following advantages and disadvantages relative to the other filtration technologies under consideration.

Advantages:

- Smallest footprint
- Designed for significantly higher hydraulic loading rates
- Low backwash rates
- Porosity of media is adjustable

Disadvantages:

- High headloss and requires an intermediate pumping station
- Fewer installations compared with traveling bridge, disk, and cloth technologies
- Filter must be taken out-of-service for backwashing

5.5 Upflow Continuous Backwash Filters

Upflow continuous backwash filters use a deep bed sand media. The process water flows upward through the media which captures the solid particles. The filter is backwashed continuously by using an airlift pump to convey the sand media and trapped particles at the bottom of the filter to a backwash trough located above the media bed. The airlift pump scours the sand and releases the trapped particles from the media as it is lifted to the backwash trough. The cleaned sand then falls to the top of the media bed and the spent backwash is discharged over a weir.

Advantages / Disadvantages. The upflow continuous backwash filter technology has the following advantages and disadvantages relative to the other filtration technologies under consideration.

Advantages:

- Established technology
- Low maintenance due to minimal moving mechanical parts
- Filter remains in service while backwashing

Disadvantages:

- Foreign objects can plug airlift pipe
- Higher headloss through filter (than traveling bridge, disk, and cloth)
- Higher backwash rates between 5 to 10 percent of total throughput

5.6 Conventional Deep Bed Filtration

Conventional deep bed filters consist of a media bed ranging in depth from 3 to 9 feet. An underdrain system is used to support the single or multimedia filter bed. During a backwash cycle, the entire filter must be taken out-of-service. A water supply reservoir and large pumps are required for backwashing of the filters. A solids separation process, such as a solids contact clarifier, is often used to separate the solids from the spent backwash water. In addition, equalization is typically provided to control the flow rate of spent backwash water back to the head of the plant.

Advantages / Disadvantages. Conventional deep bed filtration offers the following advantages and disadvantages compared with other alternatives.

Advantages:

- Proven technology and simple operation
- Deepest bed and multi-media configuration for better solids capture

Disadvantages:

- High headloss and requires an intermediate pumping station
- High backwash volume with surge flows
- Filter must be taken out of service for backwashing

5.7 Microfiltration (MF)

Microfiltration (MF) is a low pressure membrane filtration system with a membrane pore size ranging from 0.1 to 10 micrometers (μm). Particle removal is achieved through size exclusion, or "sieving". Process water is passed across a semi-permeable membrane. The treated water passing through the membrane is called filtrate, while the process water not passing is called the reject. The reject water for MF typically ranges from 10 to 15 percent of total throughput. The membranes are cleaned periodically with chemicals to remove solids and restore the hydraulic capacity.

MF is a robust filtration system with the ability to reliably to produce filtrate with a turbidity less than 0.1 NTU. MF is also proven to provide 4 log removal of Cryptosporidium and Giardia and 0.5 log removal of viruses. The installation of MF membranes provides the required level of pretreatment for potential future advanced treatment processes such as reverse osmosis (RO) and advanced oxidation for micro constituents.

MF membranes are available in two configurations, pressure vessels and submerged. Each of these configurations are presented in greater detail below.

5.7.1 Submerged – Zenon

Submerged MF systems are comprised of hollow fiber membranes or ranged in square cartridge which is then submerged in process water. A vacuum is pulled drawing the filtrate across the membrane. An air scour system is provided to agitate the water surrounding the membrane removing solids accumulation.

5.7.2 Pressure Vessels – Siemens, Pall

Pressure vessel MF systems are comprised of hollow fiber membranes enclosed within a pressurized vessel typically 6 to 8 inches in diameter. Multiple pressure vessels are grouped together on a rack with common feed water and filtrate header pipes. Backwashing of the membranes is accomplished by reversing the flow through the membranes.

Advantages / Disadvantages .Microfiltration offers the following advantages and disadvantages compared with other alternatives.

Advantages:

- Proven technology
- Highest effluent quality
- Compatible with potential future advanced oxidation technologies for removal of emerging micro-constituents
- Compatible with potential future injection wells to prevent well plugging

Disadvantages:

- High headloss and requires an intermediate pumping station
- High backwash volume
- Higher capital and operating costs

6.0 COMPARISON OF TERTIARY FILTRATION TECHNOLOGIES

This section presents an economic comparison of the tertiary filter technologies. Non-economic factors that were considered are also presented and compared.

6.1 Hydraulic Loading Criteria

Design hydraulic loading criteria for each of the filtration alternatives are summarized in Table 6.1 for the Sundog and Airport WWTPs. The resulting basis of design for Sundog and Airport WWTP filters is presented in Tables 6.2 and 6.3, respectively.

Table 6.1 Sundog and Airport WWTP Filter Hydraulic Loading Criteria						
Filter Technology	**Sundog Design Flows, mgd**		**Airport Design Flows, mgd**		**Acceptable Loading Rate, gpm/ft^2**	
	Average	**Peak (Max Month)**	**Average**	**Peak (Peak Day)**	**Average**	**Peak**
Traveling Bridge Filters	5.3	10.6	9.1	18.2	2	4
Disk Filters	5.3	10.6	9.1	18.2	3.25	6.5
Cloth Media Filters	5.3	10.6	9.1	18.2	3.25	6.5
Compressible Media Filters	5.3	10.6	9.1	18.2	30	36
Upflow Continuous Backwash Filters	5.3	10.6	9.1	18.2	3.4	5
Conventional Filters	5.3	10.6	9.1	18.2	2	5
Microfiltration	5.3	10.6	9.1	18.2	40(2)	40(2)

Note:
(1) Flux rate in gpd/ft^2

Table 6.2 Sundog WWTP Filtration Basis of Design Criteria

Filter Technology	Total Surface Area, ft²		No. Units Required		New Concrete Basin or Structure	Pump Station Required
	Average	Peak (Max Month)	Duty	Standby		
Traveling Bridge Filters	**3,120**	**3,120**	2	1	yes	no
Disk Filters	**1,764**	**1,764**	2	1	no	no
Cloth Media Filters	**2,600**	**2,600**	1	1	no	no
Compressible Media Filters	174	**253**	4	1	yes	yes
Upflow Continuous Backwash Filters	1,146	**1,526**	27	1	yes	yes
Conventional Filters	**2,400**	1,964	4	1	yes	yes
Microfiltration (2)	132,500	**265,000**	11	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based upon a standard 50 module rack.

Table 6.3 Airport WWTP Filtration Basis of Design Criteria

Filter Technology	Total Surface Area, ft^2		No. Units Required		New Concrete Basin or Structure	Pump Station Required
	Average	Peak (Peak Day)	Duty	Standby		
Traveling Bridge Filters	**4,025**	**4,025**	6	1	yes	no
Disk Filters	**2,750**	**2,750**	4	1	yes	no
Cloth Media Filters	**4,160**	**4,160**	1	1	yes	no
Compressible Media Filters	294	**400**	7	1	yes	yes
Upflow Continuous Backwash Filters	1,953	**2,582**	47	1	yes	yes
Conventional Filters	**4,200**	3,600	6	1	yes	yes
Microfiltration (2)	227,500	**455,000**	19	1	yes	yes

Notes:
(1) Bold total surface area numbers indicates governing flow condition.
(2) Based upon a standard 50 module rack.

6.2 Economic Comparison

The capital costs associated with each of the filtration technologies are summarized in Tables 6.4 and 6.5 for the Sundog and Airport WWTPs, respectively. The costs presented are for buildout flow conditions and include equipment, installation and labor. The required infrastructure includes basins and buildings, pump stations if required, general requirements, electrical and instrumentation, and contingency.

Operation and Maintenance (O&M) costs associated with each of the filtration technologies were also considered. On a life cycle analysis, O&M costs are often the controlling factor in establishing the most economic alternative. The O&M costs identified for the evaluation included labor, maintenance, power required for filtration equipment, downstream UV equipment power and chemicals.

Power consumption for UV treatment processes are typically a significant portion of the power consumption for the entire plant. Therefore, UV power consumption was evaluated for each of the filtration alternatives. Higher effluent quality increases the percent transmittance value, which lowers the UV dose required to achieve Class A+ reclaimed water quality standards.

A summary of the O&M costs associated with each of the filtration technologies are presented in Tables 6.4 and 6.5, both with and without UV power factored in, along with the present worth (PW) value of each alternative.

Table 6-4. Sundog WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Compressible Media	Upflow Filters	Conventional	Microfiltration
Capital Cost	$1,950,000	$2,166,000	$2,836,000	$2,970,000	$3,039,000	$4,740,000	$13,487,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance (parts onl	$6,200	$8,400	$4,100	$800	$1,400	$10,300	$51,000
Power ($0.10/kWH)	$8,100	$2,400	$5,900	$16,700	$16,700	$16,400	$52,600
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$114,000
Total Life Cycle Cost w/o UV	**$2,300,000**	**$2,500,000**	**$3,200,000**	**$3,400,000**	**$3,500,000**	**$5,300,000**	**$16,600,000**
UV Power	$63,100	$63,100	$63,100	$63,100	$63,100	$63,100	$19,300
Total Life Cycle Cost w/ UV	**$3,000,000**	**$3,200,000**	**$3,900,000**	**$4,100,000**	**$4,200,000**	**$6,000,000**	**$16,800,000**

Table 6-5. Airport WWTP Filtration Costs

	Traveling Bridge Filter	Disk Filter	Cloth Media Filter	Compressible Media	Upflow Filters	Conventional	Microfiltration
Capital Cost	$4,838,000	$3,818,000	$4,640,000	$4,541,000	$4,812,000	$11,676,000	$22,423,000
O&M Cost ($/year)							
Labor	$13,000	$13,000	$13,000	$13,000	$13,000	$13,000	$52,000
Maintenance	$14,000	$13,000	$4,000	$5,000	$2,000	$14,000	$42,000
Power	$19,000	$4,000	$6,000	$17,000	$16,000	$16,000	$43,000
Chemicals	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$93,000
Total Life Cycle Cost w/o UV	**$5,400,000**	**$4,200,000**	**$5,000,000**	**$5,000,000**	**$5,200,000**	**$12,200,000**	**$25,100,000**
UV Power	$110,000	$110,000	$110,000	$110,000	$110,000	$110,000	$39,000
Total Life Cycle Cost w/ UV	$6,700,000	$5,500,000	$6,200,000	$6,300,000	$6,500,000	$13,500,000	$25,500,000

6.3 Non-Economic Comparison

The preliminary screening process also considered non-economic factors. These factors are subjective but may have a significant impact on the general appeal of a technology. The non-economic factors identified for tertiary filtration were effluent quality, proven technology, operational complexity, compatibility with advanced oxidation processes (AOPs), and footprint. Table 6.6 shows a relative comparison of the filtration technologies based on a score basis of 1 through 10 (higher value means more desirable). A multiplier was also applied to each of the non-economic factors to properly weigh those factors most important to the City. The filtration technology with the highest overall total score is the most attractive process based on a comparison of these non-economic factors.

Table 6.6 Non-Economic Factor Comparison											
	Effluent Quality		**Proven Technology**		**Operational Complexity**		**Compatibility with Future AOPs**		**Footprint**		**Total Overall Score**
Weighting Factor	**x 5**		**x 4**		**x 3**		**x2**		**x2**		
Treatment Technology	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	
Traveling Bridge Filter	7	35	9	36	6	18	5	10	4	8	107
Disk Filters	7	35	9	36	8	24	5	10	8	16	121
Cloth Media Filters	7	35	7	28	7	21	5	10	6	12	106
Compressible Media Filters	6	30	4	16	5	15	3	6	8	16	83
Upflow Filters	5	25	8	32	6	18	3	6	6	12	93
Conventional Filters	7	35	9	36	3	9	5	10	3	6	96
Microfiltration	10	50	7	28	4	12	10	20	4	8	118

Comparison of non-economic factors where 10 = best and 1 = worst

7.0 SUMMARY AND RECOMMENDATIONS

The results of the tertiary filtration technologies evaluation are summarized in Table 7.1. Traveling bridge and disk filters provide the lowest overall cost and ranked third and first, respectively, in the non-economic evaluation. Microfiltration ranks high on the non-economic criteria in second place, due to process performance and compatibility with AOPs to address potential future regulations. The evaluation of cloth media, compressible media, upflow and conventional filters resulted in increased cost and lower non-economic criteria scores. Based on the evaluation traveling bridge filters, disk filters and microfiltration were selected for further consideration.

Site visits were recommended to allow City personnel an opportunity to tour facilities equipped with these technologies and discuss operational experience with the plant operators. Since the City operates two facilities equipped with traveling bridge filters with conventional underdrains, a site visit for this technology was not conducted. Pinewood Sanitation District (PSD) operates a facility in Munds Park equipped with a Gravisand type traveling bridge filters. The City of Flagstaff operates two facilities that have Kruger disk filters installed in existing traveling bridge filter bays. The filter bays are not retrofit with disk filters at the Wildcat Hill WWTP were recently refurbished with a Gravisand system. The City of Scottsdale Water campus operates both disk filters and microfiltration. Agua-Aerobic disk filters were installed in the existing conventional filter bays after an underdrain failure. Microfiltration was installed for reverse osmosis pretreatment for discharge to recharge basins. The Fountain Hills Sanitation District operates a microfiltration advanced water treatment facility (AWTF) to reduce turbidity of the WWTP's effluent prior to aquifer storage and recovery (ASR) wells to prevent well plugging.

Traveling bridge filters have performed adequately at both the Sundog and Airport WWTP but there have been some maintenance issues. There have also been effluent samples that would exceed Class A+ standards. These have occurred during peak wet weather events and correspond to operational experience at other TBF installations. TBFs perform well at average flow conditions, but experience effluent degradation due to break through at peak flow. Newer technology with relatively the same cost and fewer operational issues, prevents traveling bridge filters from being recommended for new installations.

Disk filters provide a larger filtration area in a smaller footprint then traveling bridge filters. Operator input during the site visits was favorable toward the technology. The Rio de Flag WRP operators stated a large reduction in time of maintenance relative to their old traveling bridge filters. Routine maintenance of the Kruger filters can be accomplished at operator level with out removing the filter from service. Agua-Aerobic filters require the basin to be taken off-line to access the disks and the installation require a higher side water depth than the Kruger installations. Process performance was also cited by the plant operators, specifically the ability to handle process upset with high solids loadings. The filters at the Scottsdale Water Campus have clogged to the point of overflowing the basins during one process upset but maintained effluent quality. The plant operations superintendent attributed this overflow to issues with operation rather than the performance of the equipment. The City has also recently installed disk filters at other facilities based on the performance at the Scottsdale Water Campus.

Microfiltration provides superior process performance and ability to meet future regulations. The cost of microfiltration is significantly higher than the other two technologies that also will meet Class A+ standards. Potential future regulations is one factor in accessing the viability of microfiltration, however there is a high price tag to address regulations yet to be promulgated. The Fountain Hills AWTF and Scottsdale Water Campus were equipped with microfiltration to address issues with groundwater recharge. The City does not currently have any capacity or plugging issues and ASR wells are not planned for in the near future.

Therefore, the recommended tertiary filtration alternative for implementation at the Sundog and Airport WWTPs is disk filters. Disk filters provide a good mixture of low cost, reliable performance and low maintenance.

Table 7.1 Preliminary Screening Results of Tertiary Filtration Technology

Process Name	Advantages	Disadvantages	Total PW Cost ($ mil)	Results
Traveling Bridge Filters	• Proven technology • Filter remains in service during backwash • Low backwash rates, 2 to 5 percent of total throughput • Low headloss through filter	• Moderate equipment complexity (moving parts) • Higher maintenance requirements • Less effective in handling peak loads	$7.7	Ranking: Cost – 2nd Other – 3rd
Disk Filters	• Small footprint and use of existing basins • Low headloss through filter • Very low backwash water requirements, less than 1% of throughput • Filter remains in service while backwashed • Handles peak loadings well • Simple operation, low maintenance	• Cloth media may not be compatible with polymer addition, if required for filter performance optimization • Slightly lower effluent quality compared with traveling bridge filters under normal loadings (but meets Class A+)	$ 6.7	Ranking: Cost – 1st Other – 1st
Cloth Media Filters	• Small footprint • Low headloss through filter • Very low backwash water requirements, less than 1 % of throughput • Filter remains in service while backwashed	• Moderate equipment complexity (moving parts) • Shorter performance/reliability track record in comparison with traveling bridge filters and disc filters • Cloth media may not be compatible with polymer if required for filter performance optimization • Proprietary equipment and would be difficult to achieve competitive bidding	$ 8.2	Ranking: Cost – 3rd Other – 4th
Compressible Media Filters	• Smallest footprint • Designed for significantly higher hydraulic loading rates • Low backwash rates • Porosity of media is adjustable	• High headloss and requires an intermediate pumping station • Fewer installations compared with traveling bridge, disk, and cloth technologies • Filter must be taken out-of-service for backwashing	$ 8.4	Ranking: Cost – 4th Other – 7th
Upflow Continuous Backwash Filters	• Established technology • Low maintenance due to no moving mechanical parts • Filter remains in service while backwashed	• Foreign objects can plug airlift pipe • Higher headloss through filter (than traveling bridge, disk, and cloth • Higher backwash rates between 5 to 10 percent of total throughput	$ 8.7	Ranking: Cost – 5th Other – 6th
Conventional Deep Bed Filters	• Proven technology and simple operation • Deepest bed and multi-media configuration for better solids capture	• High headloss and requires an intermediate pumping station • Highest backwash volume with surge flows • Filter must be taken out of service for backwashing	$17.5	Ranking: Cost – 6th Other – 5th
Microfiltration	• Proven Technology • Highest effluent quality • Compatible with potential future oxidation technologies for removal of emerging micro-constituents • Compatible with potential future injection wells to prevent well plugging	• High headloss and requires intermediate pumping station • High backwash volumes • Higher capital and operating costs	$ 41.7	Ranking: Cost – 7th Other – 2nd

7.1 Sundog WWTP Near Term Filter Improvements

The existing traveling bridge filters at the Sundog WWTP have recently experienced failures in the porous plates as discussed in Section 2.1. Plant operators have worked diligently to produce reasonable effluent quality. However, it is anticipated that effluent quality will deteriorate over time and it will be very difficult to achieve reasonable effluent quality during the monsoon season and peak wet weather events. For these reasons, we recommend replacement of the filters as soon as possible. Disk filters have been selected as the preferred alternative based on the evaluation conducted in this memorandum.

Two disk filter units will be required to meet maximum month flow conditions with one unit out of service, using the peaking factor determined in Section 3.0. With both units in service, the disk filters will also be able to handle peak dry weather flow events. A single traveling bridge filter bay will provide adequate tank capacity for two new disk filters. The recommended design criteria for the new disk filters is shown in Table 7.2.

Table 7.2 Sundog WWTP Disk Filter Design Criteria

Parameter	Design Criteria
Number of Units	1 (plus 1 standby)
Capacity, mgd	
AA	2.5
MM (with 1 unit out of service)	5.0
Hydraulic Loading Rate, gpm/sf	
AA	3.25
MM (with 1 unit out of service)	6.5

For planning purposes, the estimated engineering and construction costs for the new disk filters at the Sundog WWTP are summarized in Table 7.3.

Table 7.3 Sundog WWTP New Term Filter Improvements Cost

General Requirements	$125,000
Disk Filter Equipment	$1,000,000
Basin Modifications	$50.000
Electrical	$275,000
Subtotal	$1,450,000
Contingency (30%)	$435,000
Total Construction Cost	$1,885,000
Engineering Fee	$250,000
Total Cost	**$2,135,000**

ADDENDUM

1.0 SCOPE

The draft version of Technical Memorandum #7 ranked traveling bridge filters, disk filters and microfiltration as the top three filtration alternatives based on the economic and non-economic criteria. Site visits were recommended to familiarize City staff with each of the likely filtration alternatives and discuss the pros/cons with the operations staff at each of the facilities. The City operates two plants with traveling bridge filters equipped with conventional underdrains; therefore, no site visit was taken for this alternative. Site visits were conducted on June 5th and 10th to view Gravisand traveling bridge filter, disk filter and microfiltration facilities. The purpose of this technical memorandum is to summarize the results/observations of the site visits.

2.0 TRAVELING BRIDGE FILTERS - GRAVISAND

The Pinewood Sanitation District (PSD) and City of Flagstaff both operate facilities equipped with Gravisand traveling bridge filters. The PSD WWTP is rated for 600,000 gallons per day and is equipped with two Gravisand filters installed in above-grade steel tanks. At the City of Flagstaff Wildcat Hill WWTP a Gravisand pipe underdrain system was installed in the existing traveling bridge filters to replace the failed conventional underdrain system. The retrofit maintained the existing traveling bridges, replacing only the underdrain system to provide a cost effective, to reduce the cost of the installation. A similar strategy could be employed to replace the failed underdrain system of the Sundog WWTP filters.

Key observations and operator comments are listed below for the Gravisand filter installations:

- The Gravisand filters at PSD were designed without cell divider plates, while the retrofit units at the Wildcat Hill WWTP maintained the cell divider plates.
- The lack of cell divider plates at PSD resulted in a more uniform depth of filter media throughout the basin as compared to the filters at the Wildcat Hill WWTP. The cell divider plates at the Wildcat Hill WWTP appeared to produce areas of higher velocity in the center of the cell compared to the perimeter resulting in the mounding of media along the cell divider plates.
- The existing traveling bridges were maintained at the Wildcat Hill WWTP to reduce the overall cost of the filter retrofit project.
- The Wildcat Hill WWTP filters are still subject to “blinding” during process upsets requiring bypassing of the filtration process.

3.0 DISK FILTERS

Disk filter installations were viewed at the City of Flagstaff Rio de Flag WRP and Wildcat Hill WWTP, Fountain Hills WWTP and the City of Scottsdale Water Campus. The Rio de Flag WRP and Wildcat Hill WWTP are both equipped with disk filters manufactured by Kruger and have been in service for approximately one year. Both installations are a retrofit of an existing traveling bridge filter bay, which would be similar to the Sundog WWTP. The Kruger disk filters are partially submerged and allow for installation in existing traveling bridge filter bays with minimal modifications. A single traveling bridge filter bay at the Rio de Flag WRP was retrofit with three disk filter units. The second traveling bridge filter bay may be retrofit in the future to double the plant capacity without construction of additional basins.

Key observations and operator comments are listed below for the Kruger disk filter installations:

- Operators stated that the disk filters required less routine maintenance than the previous traveling bridge filters. Disk filters only require weekly inspection.
- Each disk filter is self contained with all appurtenances mounted directly on the frame.
- Operators stated that the disk filters meet all Class A+ reclaimed water quality standards.
- Effluent turbidity is slightly higher than the previous traveling bridge filters during periods of average flow conditions (still meeting required water quality standards).
- Disk filters handle peak flow and process upset (i.e. higher solids loading) events better than the traveling bridge filters.
- All maintenance of the filters and filter panel replacement can be performed at operator level without taking the filter off-line.
- Algae growth occurs within the filter on the frame supporting the filter panels. The operators at the Rio de Flag WRP have added pool chlorine tablets within the filter backwash strainer to reduce the growth of algae and maintain filter capacity. Each tablet lasts approximately one week under normal operations.
- Filter backwash events originally resulted in large flow fluctuations to the UV disinfection system. The filters have since been programmed to backwash one unit at a time to reduce the fluctuations in flow for better UV disinfection process control.
- The operators have an overall favorable opinion of the disk filters in comparison to the previous traveling bridge filters.

The Fountain Hill WWTP and Scottsdale Water Campus are both equipped with the Aqua-Aerobics disk filters. The Fountain Hills WWTP was the first installation of cloth disk filters in Arizona and has been in operation for approximately 10 years. The filters have since been upgraded with the pile cloth media, which is now a standard for Aqua-Aerobics disk filters. The Scottsdale Water Campus installed disk filters in their existing conventional filter basins after a failure of the filter underdrain. The Aqua-Aerobics disk filters have an "outside-in" flow pattern and require the disks to be fully submerged for proper operation resulting in a deeper basin depth than the Kruger disk filters.

Key observations and operator comments are listed below for the Aqua-Aerobics disk filter installations:

- A deeper basin is required to provide full submergence of the disks resulting in additional modifications to traveling bridge filter bays for retrofit with disk filters.
- The disk filters at the Water Campus experienced a "blinding" event due to a upset within the plant process resulting in unfiltered secondary effluent overtopping the filter bays. The plant operations superintendent attributed this event to operational issues rather than filter design or performance.
- The amount of backwash water is significantly less than that of conventional filtration and does not require flow equalization of the backwash water sent to the head of the plant.
- The disk filters remain in service during filter backwash.
- The Aqua-Aerobics disk filters are required to be off-line during service/replacement of the filter panels reducing the filtration capacity of the system.
- The backwash pumps are located external to the disk filter units requiring additional piping, valves and control.

4.0 MICROFILTRATION

Microfiltration installations were viewed at the Fountain Hill Advanced Water Treatment Facility (AWTF) and the City of Scottsdale Water Campus. Both installations were designed to meet requirements for groundwater recharge, specifically to prevent clogging in the recharge wells and basins. The microfiltration units were installed at the Water Campus in 1999 and at the Fountain Hills AWTF in 2001. Both systems lack the advanced automation and control features of more recent installation, however little has changed with the actual filter cartridge design. The microfiltration processes at both facilities require significant infrastructure and equipment for proper operation including influent pumps, strainers and chemical feed systems.

Key observations and operator comments are listed below for the microfiltration installations:

- Microfiltration was employed at the Fountain Hill AWTF to reduce turbidity and prevent clogging of the aquifer storage and recovery (ASR) wells.
- Microfiltration at the Water Campus was employed as a pretreatment process for the reverse osmosis (RO) membranes.

- Each rack contains multiple cartridges, however each of the individual cartridges can be isolated and repaired in place without taking the entire rack off-line.
- Chemical cleaning is required to maintain capacity necessitating multiple chemical feed systems.
- The complexity of the process requires increased operator attention and routine maintenance.
- Microfiltration provides superior and more consistent process performance over the other filtration alternatives visited.
- Membranes are typically operated at a constant flux rate with little to no peaking capacity. This requires the installation of additional filter elements to handle the peak flow of the system.

CITY OF PRESCOTT
Everybody's Hometown

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 8
Biosolids Planning Conditions

Final

In Association with

Project No. 164890

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City of Prescott

TECHNICAL MEMORANDUM
NO. 8
BIOSOLIDS PLANNING CONDITIONS

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ES8 TM 8 – BIOSOLIDS PLANNING CONDITIONS

ES8.1 Introduction

The main objectives of this Technical Memorandum No. 8 are to establish existing conditions and identify future trends in biosolids management. Existing conditions of solids handling equipment, materials, processes, and costs are established. Future trends in regional land use and availability, as well as regulatory issues are identified as they relate to the City's biosolids management program.

ES8.2 Background

Biosolids are typically disposed of in landfills or are beneficially reused through land application. Biosolids disposal and land application is federally regulated by the EPA 40 CFR 503. The Arizona Department of Environmental Quality (ADEQ) enforces the federal regulations and administers the biosolids program in Arizona, with oversight by the U.S. EPA. Table 8.4 presents a brief summary of the ADEQ, Class A, and Class B biosolids requirements and associated land application restrictions. A more detailed discussion of EQ, Class A, and Class B biosolids regulations are provided in Appendix A of Technical Memorandum No. 8.

Table ES8.1 Biosolids Classifications and Disposal Options Summary
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

	Exceptional Quality	Class A	Class B
Requirement	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Achieve pathogen and vector attraction reduction.
	Reduce pathogen levels to below detectable limits.	Reduce pathogen levels to below detectable limits.	
	Achieve vector attraction reduction via limited options.	Achieve vector attraction reduction.	
	Must meet monthly average metal concentration limits.	Must meet ceiling metal concentration limits and metal loading rates.	

Table ES8.1	Biosolids Classifications and Disposal Options Summary Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona		
	Exceptional Quality	**Class A**	**Class B**
Can be applied to…	Anywhere.	Nurseries, gardens, golf courses, parks, and areas where contact with general public is possible.	Agriculture, landfill, & areas with no potential contact with general public.

ES8.3 Existing Conditions

The Sundog WWTP produces Class B biosolids that are disposed of via land application. Solids handling and treatment facilities at the Sundog WWTP include waste activated sludge (WAS) thickening, anaerobic digestion of combined primary sludge and thickened WAS, and dewatering of digested sludge.

The current solids handling practice at the Airport WRF is dewatering undigested sludge, followed by landfill disposal. WAS is continuously pumped to an aerated solids holding tank, where it is slightly thickened by gravity. The thickened WAS is sent to the centrifuge building for dewatering and subsequent disposal via a roll-off bin.

The current biosolids management program costs include processing, hauling, and disposal of the biosolids generated at the Sundog WWTP and Airport WRF. The costs of the biosolids management program are summarized in Table 8.10. Since April 2009, biosolids from the Airport WRF are not sent to the Sundog WWTP, and are sent to landfill disposal after dewatering. Biosolids from the Sundog WWTP are disposed of via land application.

The overall unit cost for biosolids management at the Airport WRF is 74 percent higher than the costs at the Sundog WWTP. The main reason for this difference is the higher disposal cost associated with the Airport WRF sludge ($29.50 per wet ton for land application, versus $47.00 per wet ton for landfill disposal).

Table ES8.2	**Existing Biosolids Management Program Costs Summary Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona**			
Cost [1]	**Sundog WWTP**		**Airport WRF**	
Annual Energy Costs	$41,493	(24%)	$22,888	(21%)
Annual Chemical Costs	$24,220	(14%)	$31,415	(29%)
Annual Biosolids Disposal Costs[2],[3]	$105,394	(61%)	$52,235	(49%)
Annual Miscellaneous Costs	$2,972	(2%)	$301	(0.3%)
Total Annual Operating Costs	$174,079	(100%)	$106,839	(100%)
Biosolids Produced [2]	3,334 wet tons		1,159 wet tons	
Unit Cost	$52.2 / wet ton		$92.2/ wet ton	

Notes:

(1) All costs are based on 2009 process operational data and cost information provided by City of Prescott. A detailed breakdown is presented in Appendix B.

(2) Quantities of Airport WRF biosolids in the first three months of 2009 were estimated using a monthly average of April to December 2009.

(3) The current contract for biosolids transport and disposal establishes a fixed cost of $29.5 per wet ton for land application, and $47.0 per wet ton for landfill disposal.

ES8.4 Biosolids Quantities

Existing and future solids production for the Sundog WWTP and Airport WRF are presented in Table 8.11.

Table ES8.3	**Existing and Projected Biosolids Production – Sundog WWTP and Airport WRF Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona**					
	Sundog WWTP Plant Flow	**Airport WRF Plant Flow**	**Sundog WWTP Dewatered Biosolids**		**Airport WRF Dewatered Biosolids**	
	mgd	**mgd**	**lb/day**	**wet tons/ day [2]**	**lb/day**	**wet tons/ day [2]**
Existing [1], AADF	2.6	1.1	3,653	9.1	1,389	3.2
Existing, MMADF	5.2	1.5	6,377	15.9	2,729	6.2
Ultimate, AADF	5.4	9.6	7,588	19.0	16,371	40.9
Ultimate, MMADF	10.8	13.4	13,244	33.1	29,479	73.7

Notes:
(1) Based on 2009 operational data
(2) Assumes a total solids concentration of 20 percent.

ES8.5 Biosolids Management Trends

There are no specific new federal regulatory initiatives planned in the near-term. Similar to regulations for liquid processes in wastewater treatment, personal health care products and pharmaceuticals in biosolids is an issue on the horizon, but no impending regulatory programs are envisioned to address these compounds in the near future.

There are no formal restrictions for the land application of biosolids in the State of Arizona. However, a number of counties in California have implemented full or partial bans of Class B biosolids land application. Others have restricted the application of biosolids entirely - regardless of their classification.

Most facilities in Arizona produce either Class B or unclassified biosolids, with only a few facilities producing Exceptional Quality or Class A biosolids.

The City's biosolids are currently applied at either the Hauser and Hauser site or at the Orme Ranch site. However, there are other registered land application sites within a similar distance from Prescott. In the short term, there are no apparent land availability issues for Class B biosolids produced from the City.

The future trend in land availability for Yavapai County is generally consistent with trends occurring in the State of Arizona, particularly in other Counties experiencing significant population growth. The statewide trend shows a reduction in farmland acreage. The rate (percentage) of farmland acreage loss in Yavapai County is significantly greater than the statewide trend, but similar to other fast-growing counties such as Maricopa County and Yuma County.

In general, there are no indications in the short-term that would indicate an urgent need to take the existing level of biosolids treatment beyond Class B quality. In the long-term, production of Exceptional Quality or Class A biosolids can provide an improved degree of flexibility for biosolids disposal given the trends of reduced availability of cropland areas and increased concerns from the general public. However, a detailed analysis of disposal alternatives is recommended before embarking on investments towards the production of Class A or Exceptional Quality biosolids, in order to analyze the cost-benefits of the increased level of biosolids treatment.

There are no regulatory issues in the horizon that would significantly affect biosolids management in the short and medium term. However, the potential risks posed by of micro constituents and emerging contaminants are currently being evaluated at the research level.

1.0 INTRODUCTION

This technical memorandum is part of the Master Planning, Design, and Local Limits project for the City of Prescott Airport Wastewater Reclamation Facility (WRF) and Sundog Wastewater Treatment Plant (WWTP). This Technical Memorandum (TM) No. 8 is one of the elements of Part 3 – Airport and Sundog WWTPs Biosolids Master Plan, and it addresses Task Group 1100 – Define Planning Conditions.

The main objectives of this TM No. 8 are:

- To establish and document current conditions in regards to solids handling equipment, materials and processes.
- To establish and document current biosolids management program costs, including processing, hauling, tipping fees, and disposal costs.
- To identify future trends in regional land use and land availability for biosolids disposal.
- To identify future regulatory trends that impact the current biosolids management program, as well as to identify regional and national trends and practices at other municipal facilities in the region.
- To establish the projected biosolids quantities based on historical solids production in conjunction with future increases in flows and loads.

1.1 Reference Documents

The following reference documents were used for the preparation of this TM No. 8:

- Code of Federal Regulations Title 40, Section 503 (40 CFR 503). U.S. Environmental Protection Agency (U.S. EPA).
- Arizona Administrative Code, Title 18 - Environmental Quality. Chapter 9, Supplement 05-3, Article 10. State of Arizona.
- Sundog WWTP and Airport WRF Operational Data.

2.0 BACKGROUND

Two terms are commonly used to describe the solids generated by a typical wastewater treatment process - “sludge” and “biosolids”. The term “sludge” is generally used to describe wastewater solids prior to stabilization and in conjunction with a specific process descriptor, such as in “primary sludge,” “waste activated sludge,” or “secondary sludge.” Biosolids are defined as organic solid residuals resulting from the treatment of domestic sewage at a wastewater treatment facility. The term “biosolids” is promoted by The Water Environment Federation to indicate that wastewater solids are organic products, which have beneficial end-use properties. Sludge generated by a wastewater treatment facility is defined as biosolids once beneficial use criteria (as determined by compliance with the U.S. EPA 40 CFR 503) have been achieved through stabilization processes. Stabilization processes are described as those that help reduce pathogens, reduce vector attraction, and eliminate offensive odors and the potential for decomposition.

2.1 Biosolids Disposal Regulations

Biosolids are typically disposed of in landfills or are beneficially reused through land application. The broad category of land application includes all forms of applying bulk biosolids to land for beneficial use at agronomic rates (i.e. the nutrient uptake of the associated crop that the biosolids fertilize). As nitrogen is typically the limiting nutrient, the biosolids application must match the crop’s nitrogen uptake rate.

Biosolids disposal and land application is federally regulated by the EPA 40 CFR 503. The Arizona Department of Environmental Quality (ADEQ) enforces the federal regulations and administers the biosolids program in Arizona, with oversight by the U.S. EPA. Biosolids disposal in Arizona is regulated under the Arizona Administrative Code, Title 18, Chapter 9, Article 10.

2.1.1 Biosolids Classifications

The 40 CFR 503 regulations classify biosolids as Exceptional Quality (EQ), Class A or Class B according to the level of treatment provided to reduce pathogens and vector attraction. Pathogens are defined as disease-causing organisms such as bacteria, viruses, and parasites. The reduction of pathogens in biosolids is necessary to prevent the spread of disease. Pathogens can be carried and transferred via vectors such as flies, mosquitoes, fleas, rodents, and birds. To further prevent the spread of disease-laden pathogens, biosolids must also be treated to reduce their attractiveness to vectors.

The 40 CFR Part 503 regulations also regulate the allowable biosolids inorganic content (i.e. heavy metals). Lower inorganic content further reduces the restrictions placed on beneficial use practices. EQ is the highest quality defined by the 503 regulations. EQ biosolids have very low heavy metal content and have been treated to Class A pathogen and vector attraction reduction levels.

Class B biosolids may only be applied where there is no possibility of contact with the general public (i.e. certain types of agriculture, landfill, etc.). Additional restrictions associated with Class B biosolids prevent crop harvesting, animal grazing, and public access for a defined period of time until environmental conditions have further reduced pathogens. EQ and Class A biosolids, however, have less stringent requirements associated with application and may be land applied where contact with the general public is possible (i.e., nurseries, gardens, golf courses, etc.). The 503 regulations allow unrestricted distribution and reuse of EQ biosolids up to agronomic limits. **Ultimately, the higher the level of treatment to reduce pathogens and vector attraction, the fewer restrictions there are for beneficial reuse.**

Table 8.4 presents a brief summary of the EQ, Class A, and Class B biosolids requirements and associated land application restrictions. More detailed discussion of EQ, Class A, and Class B biosolids regulations are provided in Appendix A.

Table 8.4 Biosolids Classifications and Disposal Options Summary
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

	Exceptional Quality	Class A	Class B
Requirement	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Fecal coliform density <1000 MPN/g total dry solids **or** *Salmonella* density <3 MPN/4 g total dry solids.	Achieve pathogen and vector attraction reduction.
	Reduce pathogen levels to below detectable limits.	Reduce pathogen levels to below detectable limits.	
	Achieve vector attraction reduction via limited options.	Achieve vector attraction reduction.	
	Must meet monthly average metal concentration limits.	Must meet ceiling metal concentration limits and metal loading rates.	
Can be applied to…	Anywhere.	Nurseries, gardens, golf courses, parks, and areas where contact with general public is possible.	Agriculture, landfill, & areas with no potential contact with general public.

3.0 EXISTING CONDITIONS

The City of Prescott owns and operates two wastewater treatment plants with different levels of biosolids treatment. The Sundog WWTP employs anaerobic digestion for sludge stabilization, and produces Class B biosolids suitable for land application. The Airport WRF does not have sludge stabilization processes at the moment; waste activated sludge is currently dewatered and sent to landfills for disposal. The City currently has contracted operations for biosolids transport and disposal from both treatment facilities to either landfill disposal or land application sites.

Currently, the City's Class B biosolids are land applied at either the Hauser and Hauser site or at the Orme Ranch site near Prescott. Unclassified sludge is sent to the Gray Wolf Landfill (owned and operated by Waste Management of Arizona, Inc.).

3.1 Existing Processes at Sundog WWTP

Solids handling and treatment facilities at the Sundog WWTP include waste activated sludge (WAS) thickening, anaerobic digestion of combined primary sludge and thickened WAS, and dewatering of digested sludge. The resulting Class B biosolids are disposed of via land application.

3.1.1 WAS Thickening

Two gravity belt thickeners (one duty and one standby that has been used to supply replacement parts for the duty unit) are used to thicken waste activated sludge prior to anaerobic digestion. Thickened sludge pumps deliver thickened sludge to the anaerobic digesters. Design criteria for the gravity belt thickeners is presented in Table 8.5.

Table 8.5	Sundog WWTP Waste Activated Sludge Thickening Design Criteria Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona
Thickening units	
Number	2 (1 duty)
Type	Gravity Belt
Hydraulic capacity, gpm	100
Maximum solids loading, lb/day	4,540
Belt width, meters	1.0
Motor horsepower, each	1
Thickened WAS pumps	
Number	2 (1 duty + 1 standby)
Type	Progressive cavity
Rated capacity, gpm	50
Normal pressure range, psi	8-12
Motor horsepower, each	5

3.1.2 Anaerobic Digestion

Sludge stabilization is achieved by anaerobic digestion of primary sludge and thickened WAS. The digestion facilities include two anaerobic digesters operating in series. The primary digester has a fixed cover, and the secondary digester has a floating cover. Piping and equipment are provided and configured so that the secondary digester can serve as a standby primary digester. Design criteria for the anaerobic digestion facilities is presented in Table 8.6.

Table 8.6	Sundog WWTP Anaerobic Digestion Facilities Design Criteria Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona
Anaerobic digesters	
Number of digesters	2
Diameter, ft	50
Sidewater depth, ft	25
Volume each, ft^3	49,000
Primary digester max month SRT, days	12.1
Primary digester max month volatile solids loading, ppd/1000 ft^3	163
Existing average gas production, ft^3/day	35,000
Gas heat value, MBtu/day	32.3
Max month heat required, MBtu/day	12.9
Digester mixing	
Type	Draft tube mechanical mixers

Table 8.6	Sundog WWTP Anaerobic Digestion Facilities Design Criteria Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona
Number circulating capacity per unit, gpm	7,600
Motor horsepower	5
Sludge heaters	
Type	Combination boiler/heat exchanger
Number	2 (incl. 1 standby)
Boiler rating, MBtu/hr	1.0
Exchanger capacity, MBtu/hr	0.5
Sludge recirculation pumps	
Number	SRP-1 & 2
Type	Horizontal end suction chopper
Rated capacity, gpm	350
Rated head, ft	13
Motor horsepower	7.5
Digester sludge pumps	
Number	2
Type	Progressing cavity
Rated capacity, gpm	100
Pressure range, psi	2-5
Motor horsepower	7.5

3.1.3 Dewatering

Biosolids dewatering is achieved with belt press dewatering equipment. Shortly after completion of the 1990 improvements, the City purchased and installed one belt dewatering press in a temporary structure. A permanent belt press facility was included in the 1990 project design, but was postponed for budget reasons. Design criteria for the belt dewatering press is presented in Table 8.7.

Table 8.7	Sundog WWTP Belt Press Design Criteria Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona
Number of units	1
Belt width, meters	2
Motor horsepower	5
Polymer	Dry system
Batch tanks	2
Volume, gals	350
Metering pumps	1

3.2 Existing Processes at Airport WRF

New solids handling facilities were added to the Airport WRF as part of the Centrifuge Building and Equipment Installation Project in 2009. Sludge dewatering operations with the new solids handling facilities began in April 2009. An older secondary clarification basin was converted into an aerated solids holding tank, and a new building was added to the plant facilities, which includes a dewatering centrifuge and its associated equipment.

The current solids handling practice at the Airport WRF is dewatering undigested sludge, followed by landfill disposal. WAS is continuously pumped to the aerated solids holding tank. The solids in the holding tank are aerated and mixed. To achieve additional thickening of the WAS, aeration is stopped for short periods to allow solids settling. Decant from the settling operation in the solids holding tank is sent back to the secondary treatment process. The thickened WAS is sent to the centrifuge building for dewatering and subsequent disposal via a roll-off bin.

3.2.1 Solids Holding

The secondary clarifier built in the initial phase of the Airport WRF (1976 project) has been converted into a solids holding tank, by removing the secondary clarification mechanism and performing several modifications. WAS is continuously pumped into the solids holding tank over the course of the day using the RAS pumps and a flow control valve. Aeration and mixing is provided with a coarse bubble diffuser system and a positive displacement blower. Submersible pumps in the solids holding basins are used to pressurize the WAS line connected to the centrifuge feed pumps located in the centrifuge building. The solids holding tank description is summarized in Table 8.8.

Table 8.8	Airport WRF Solids Holding Tank Description Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona
Tank dimensions	
Tank diameter, feet	50
Side water depth, feet	Variable up to 8
Aeration system	
Number of blower units	1
Motor horsepower	20
Diffuser type	Coarse bubble, 2 ft units
Number of diffusers	56
Thickened WAS pumps	
Pump type	Submersible, open bottom, non-clog centrifugal (Flygt, type "N" impeller)
Number of units	2
Capacity, gpm	333 (1)
Rated head, ft	12.8 (1)
Motor control	One unit with variable frequency drive. One unit constant speed.
Motor horsepower, each	3

Note:

(1) Based on duty point in pump curve provided by plant staff.

3.2.2 Dewatering

A new centrifuge building was constructed in April 2009, and is located at the southeast end of the existing plant site. The centrifuge building includes one dewatering centrifuge, with its associated sludge grinder, feed pump, and polymer feed system. Provisions have been made for the installation of a second dewatering centrifuge unit and its associated equipment. The design criteria for the existing dewatering system is summarized in Table 8.9.

Table 8.9 Airport WRF Dewatering Centrifuge System Design Criteria
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

Dewatering centrifuge	
Manufacturer	Centrisys
Number of units	1 (1)
Hydraulic loading capacity, gpm	50 to 70 (2)
Feed solids concentration, percent	0.6 to 2.5 (average: 1.0)
Maximum solids loading capacity, lbs/hr	575
Minimum solids capture, percent	95
Minimum cake solids content, percent	20
Motor horsepower, main drive	30
Motor horsepower, back drive	10
Sludge grinder	
Type	In-line (Boerger)
Number of units	1 (1)
Capacity, gpm	70
Motor horsepower	5
Centrifuge feed pump	
Pump type	Progressive cavity (Netzch)
Number of units	1 (1)
Capacity, gpm	70
Discharge pressure, psi	100
Suction pressure	Flooded
Maximum solids concentration, percent	12
Motor horsepower	7.5
Polymer feed system	
Type	Liquid polymer blending system (Velodyne)
Number of units	1 (1)
Neat polymer metering pump	Progressive cavity, 1 to 10 gph
Dilution water inlet	1 to 10 gpm
Polymer mixing chamber	Staged hydrodynamic (non-mechanical)

Notes:

(1) Provisions in existing building allow two units to be installed.

(2) At feed solids (WAS) concentrations between 0.6 and 2.5 percent solids. Includes polymer flow and dilution water.

3.3 Existing Costs

The current biosolids management program costs include processing, hauling, and disposal of the biosolids generated at the Sundog WWTP and Airport WRF. Operational data as well as cost information were provided by the City for the purposes of this Task. The costs of the biosolids management program are summarized in Table 8.10. It should be noted that for the first three months of 2009, solids produced at the Airport WRF were sent to the Sundog WWTP for treatment and final disposal. Since April 2009, biosolids from the Airport WRF are not sent to the Sundog WWTP, and are sent to landfill disposal after dewatering. Biosolids from the Sundog WWTP are disposed of via land application. A more detailed breakdown of the biosolids management program costs is included in Appendix B.

Table 8.10 Existing Biosolids Management Program Costs Summary
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

Cost [1]	Sundog WWTP		Airport WRF	
Annual Energy Costs	$41,493	(24%)	$22,888	(21%)
Annual Chemical Costs	$24,220	(14%)	$31,415	(29%)
Annual Biosolids Disposal Costs [2],[3]	$105,394	(61%)	$52,235	(49%)
Annual Miscellaneous Costs	$2,972	(2%)	$301	(0.3%)
Total Annual Operating Costs	$174,079	(100%)	$106,839	(100%)
Biosolids Produced [2]	3,334 wet tons		1,159 wet tons	
Unit Cost	$52.2 / wet ton		$92.2/ wet ton	

Notes:

(1) All costs are based on 2009 process operational data and cost information provided by City of Prescott. A detailed breakdown is presented in Appendix B.

(2) Quantities of Airport WRF biosolids in the first three months of 2009 were estimated using a monthly average of April to December 2009.

(3) The current contract for biosolids transport and disposal establishes a fixed cost of $29.5 per wet ton for land application, and $47.0 per wet ton for landfill disposal.

The overall unit cost for biosolids management at the Airport WRF is 74 percent higher than the costs at the Sundog WWTP. The main reason for this difference is the higher disposal cost associated with the Airport WRF sludge. Since the Airport WRF does not employ sludge stabilization processes, all the sludge produced must be disposed at landfills. The City's current biosolids transport and disposal contract establishes a landfill disposal cost 59 percent higher than disposal to land application sites ($29.50 per wet ton for land application, versus $47.00 per wet ton for landfill disposal). Evaluation of solids treatment alternatives during master planning activities in this project shall reflect the different costs associated with landfill disposal versus land application.

4.0 BIOSOLIDS QUANTITIES

Existing and future solids production for the Sundog WWTP is presented in Table 8.11. Biosolids production for the Airport WRF is summarized in Table 8.12.

Table 8.11 Existing and Projected Biosolids Production – Sundog WWTP
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

	Plant Flow	Primary Sludge	WAS	Dewatered Biosolids	
	mgd	lb/day	lb/day	lb/day	wet tons/day(2)
Existing (1), AADF	2.6	3,923	3,200	3,653	9.1
Existing, MMADF	5.2	6,255	6,100	6,377	15.9
Ultimate, AADF	5.4	8,147	6,646	7,588	19.0
Ultimate, MMADF	10.8	12,991	12,669	13,244	33.1

Notes:
(1) Based on 2009 operational data
(2) Assumes a total solids concentration of 20 percent.

Table 8.12 Existing and Projected Biosolids Production – Airport WRF
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

	Plant Flow	Primary Sludge	WAS	Dewatered Biosolids	
	mgd	lb/day	lb/day	lb/day	wet tons/day(2)
Existing (1), AADF	1.1	-	1,870	1,389	3.2
Existing, MMADF	1.5	-	3,674	2,729	6.2
Ultimate, AADF	9.6	27,116	6,127	16,371	40.9
Ultimate, MMADF	13.4	43,893	15,382	29,479	73.7

Notes:
(1) Based on 2009 operational data
(2) Assumes a total solids concentration of 20 percent.

5.0 BIOSOLIDS MANAGEMENT TRENDS

Biosolids management programs are strongly driven by regulatory and land availability issues, which in turn impact the overall costs of biosolids management. Stricter regulations and reduced availability of disposal sites close to urbanized areas result in higher costs for biosolids management programs. The purpose of this Section is to review regulatory as well as land availability trends in relation to the City's biosolids management program.

5.1 Regulatory Trends

The U.S. EPA Region IX includes the States of Arizona, California, Nevada, and Hawaii. Most states have long-standing regulations that control how biosolids can be utilized or disposed. Few states have received delegation of the Federal program; Arizona is one of eight to ten states that have pursued this.

In Arizona, biosolids land application and disposal is regulated by the Arizona Department of Environmental Quality (ADEQ) as codified in 18 Arizona Administrative Code (A.A.C.) 9, Article 10, entitled Arizona Pollutant Discharge Elimination System - Disposal, Use and Transportation of Biosolids (A.C.C. R18-9-10.).

5.1.1 Federal Regulations Trends

There are no specific new regulatory initiatives planned in the near-term. Similar to regulations for liquid processes in wastewater treatment, personal health care products and pharmaceuticals in biosolids is an issue on the horizon, but no impending regulatory programs are envisioned to address these compounds in the near future. It is worth noting that the Water Environment Research Foundation (WERF) is currently conducting a research project on the fate of estrogenic compounds (*Fate of Estrogenic Compounds during Municipal Sludge Stabilization and Dewatering*) to provide baseline information to better understand the risks posed by the presence of estrogenic compounds in biosolids.

The Clean Water Act requires the EPA to review the 503 regulations at least every two years for the purpose of identifying additional toxic pollutants in sewage sludge and promulgating regulations for such pollutants consistent with the requirements of Section 405 (d). In 2001, the EPA commissioned the National Research Council (NRC) to evaluate the technical basis for the pollutant and pathogen standards of the 503 rule. In 2003, in response to the NRC's 2002 report entitled Biosolids Applied to Land: Advancing Standards and Practices, the EPA agreed to undertake a new national survey of chemicals and pathogens in biosolids and to consider additional pollutants that should be regulated. These additional pollutants are referred to as the "Round 3" and "Round 4" pollutants.

For Round 3, EPA evaluated existing sewage sludge regulations and compiled a list of 803 additional toxic pollutants in sewage sludge for potential future regulations. Based on an exposure and hazard screening assessment of chemical pollutants for which EPA had adequate data (i.e., human health benchmark values and information on fate and transport in the environment), as well as concentration data in sewage sludge for those pollutants, EPA identified 15 pollutants for possible regulation (acetone, anthracene, barium, beryllium, carbon disulfide, 4-chloroaniline, diazinon, fluoranthene, manganese, methyl ethyl ketone, nitrate, nitrite, phenol, pyrene, and silver); this list has since been reduced to nine.

Round 4 considered a preliminary list of 137 pollutants, but EPA reports that at the present time there is insufficient data on any of these to proceed with risk assessments.

Class A Alternatives 3 and 4 are being reviewed by EPA, and may be eliminated. These alternatives involve pre-processing and/or post-processing analyses of the biosolids to demonstrate that the densities of viable helminth ova, enteric viruses, Salmonella and fecal coliform meet the Class A limits. These alternatives are utilized predominantly by smaller generators whose biosolids are either processed by lower technology options (e.g. air drying, vermin-composting) or whose influent tends to exhibit low natural populations of these pathogens. In the place of Alternatives 3 and 4, Regions or states would have the opportunity to approve site-specific conditions in conjunction with the U.S. EPA's Pathogen Equivalency Committee.

5.1.2 State and Local Regulations Trends

There are no formal restrictions for the land application of biosolids in the State of Arizona. However, a number of counties in California have implemented full or partial bans of Class B biosolids land application. Others have restricted the application of biosolids entirely - regardless of their classification. The counties in California that have no current legislation banning biosolids are primarily urban areas where land application is not a practical issue.

As a result of the various bans and restrictions on biosolids application in Southern California and increasing public concern, many Southern California municipalities have resorted to transporting Class B biosolids to agricultural lands in Arizona, where less stringent restrictions exist. Due to the influx of Class B biosolids from California, along with changing land uses throughout the state, the availability of land for application of Class B biosolids in Arizona is continually decreasing. In addition, some Arizona counties are considering restrictions on Class B biosolids land application, similar to those already implemented in California.

A case worth mentioning in local regulation trends is the Kern County case, which has recently received national attention. Kern County was seeking to enforce a local ordinance banning land application of biosolids from the City of Los Angeles and other Southern California agencies. The litigation between City of Los Angeles and Kern County was taken to a federal court, and a federal Judge found the ban to be illegal, which prevented Kern County from enforcing the ban on land application of biosolids. Organizations such as the Water Environment Federation (WEF) and the National Association of Clean Water Agencies (NACWA) have filed documentation supporting the position that individual municipalities should be able to choose the method of biosolids management that works best for their communities, including the option of land application. According to the National Biosolids Partnership (NSP), the outcome of the Kern County case has the potential to have a significant impact on biosolids programs in every state, because this will be the first appellate decision on whether biosolids bans are legal under the Federal Constitution.

Based on the continually changing status of regulations associated with biosolids disposal, any decisions regarding long-term biosolids management practices must carefully consider the dynamics of local biosolids regulations. These changing regulations, and the resulting availability of application sites, can ultimately have significant impacts on the potential applicability of various biosolids management options.

5.1.2.1 Biosolids-to-Energy

The current Arizona Administrative Code prohibits incineration of biosolids (A.A.C. R18-9-1002.G). Therefore, technologies that involve incineration of biosolids, with or without energy recovery, are currently not allowed to operate in the State of Arizona. Technologies are developing rapidly and have advanced to a point where previous concerns with air emissions have been addressed. It is recommended to monitor state legislation for possible changes allowing certain forms of biosolids-to-energy technologies to operate in Arizona.

5.1.3 Biosolids Management Practices in Arizona

Various biosolids management alternatives are currently practiced throughout the State of Arizona, and are summarized in Table 8.13. Most facilities in Arizona produce either Class B or unclassified biosolids, with only a few facilities producing Exceptional Quality or Class A biosolids.

Table 8.13 Regional Biosolids Quality and Management Practices
Technical Memorandum No. 8 – Biosolids Planning Conditions
City of Prescott, Arizona

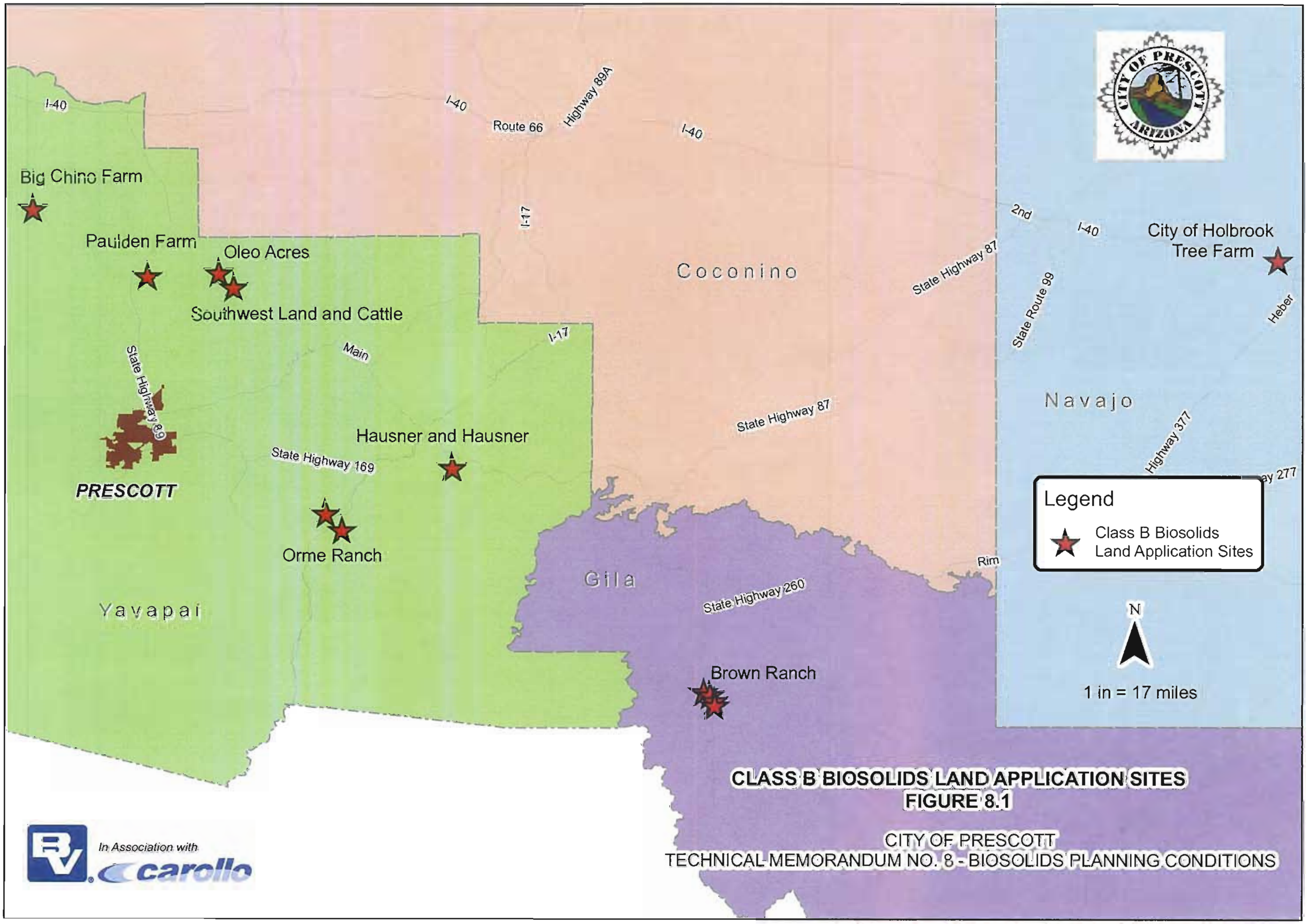
Wastewater Treatment Facility	Biosolids Quality	Disposal Method
Avondale WWTP	Class B	Land Application
Casa Grande Water Reclamation Facility (WRF)	Class B	Land Application
Chandler Airport WRF	Unclassified	Landfill
Chandler Ocotillo WRF	Unclassified	Landfill
Flagstaff - Rio De Flag WRP	Class B	Surface Disposal
Flagstaff - Wildcat Hill WWTP	Class B	Surface Disposal

Table 8.13	Regional Biosolids Quality and Management Practices Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona	
Wastewater Treatment Facility	**Biosolids Quality**	**Disposal Method**
Fountain Hills WWTP	Unclassified	Landfill
Goodyear	Class B	Land Application
Nogales WWTP	Class B	Land Application
Northern Gila County Sanitation District	Exceptional Quality	Land Application / Distribution in Bags
Phoenix - 23rd Avenue WWTP	Class B	Land Application
Phoenix - 91st Avenue WWTP	Class B	Land Application
Pima County - Avra Valley WRP	Class B	Landfill
Pima County - Ina Road WWTP	Class B	Land Application
Pima County - Roger Road WWTP	Class B	Land Application
Pinetop-Lakeside WWTP	Class A	Land Application
Prescott Valley	Class B	Land Application and Landfill
Surprise WWTP	Exceptional Quality	Land Application
Tolleson WWTP	Exceptional Quality	Sold to Composter
Yuma - Desert Dunes WRF	Class B	Land Application
Yuma - Figueroa Water Pollution Control Facility (WPCF)	Class B	Land Application

5.2 Land Availability Trends

Biosolids Class B biosolids land application sites (registered with ADEQ) near Prescott are shown in . The City's biosolids are currently applied at either the Hauser and Hauser site or at the Orme Ranch site. However, there are other registered land application sites within a similar distance from Prescott. In the short term, there are no apparent land availability issues for Class B biosolids produced from the City.

Historical changes in total farmland acreage provide a general trend of land availability for land application of biosolids. summarizes the changes in total farmland acreage within Yavapai County between 1997 and 2007 according to the United States Department of Agriculture (USDA) National Agricultural Census (1997, 2000, and 2007). The general trend for Yavapai County is a reduction of total farmland acreage at a rate of between 10 and 11 percent every 5 years.



CLASS B BIOSOLIDS LAND APPLICATION SITES
FIGURE 8.1

CITY OF PRESCOTT
TECHNICAL MEMORANDUM NO. 8 - BIOSOLIDS PLANNING CONDITIONS

Date Printed: August 13, 2010
File Location: M:\Client\Prescott\8286A.00\Analysis\Maps\Class B Biosolids Land App Sites_rev.mxd

Table 8.14	Yavapai County Farmland Acreage Historical Data Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona		
Year	**Total Land in Farms (1)**	**Acreage Loss**	**Percent Decrease**
1997	797,574	-	-
2002	720,362	77,212	10
2007	639,042	81,320	11

Note:

(1) Source: United States Department of Agriculture (USDA) National Agricultural Census.

The trend in land availability for Yavapai County is generally consistent with trends occurring in the State of Arizona, particularly in other Counties experiencing significant population growth. Table 8.15 presents a comparison between the decrease in total farmland acreage for Yavapai County, Maricopa County, Yuma County, and the State of Arizona between 1997 and 2007. The statewide trend shows a reduction in farmland acreage. The rate (percentage) of farmland acreage loss in Yavapai County is significantly greater than the statewide trend, but similar to other fast-growing counties such as Maricopa County and Yuma County.

Table 8.15	Farmland Acreage Historical Trends Comparison Technical Memorandum No. 8 – Biosolids Planning Conditions City of Prescott, Arizona			
	Percent Decrease in Total Farmland Acreage (1)			
Period	**Yavapai County**	**Maricopa County**	**Yuma County**	**State of Arizona**
1997 - 2002	10	15	9	2
2002 - 2007	11	23	9	2

Note:

(1) Calculated from United States Department of Agriculture (USDA) National Agricultural Census data.

As part of a recent Biosolids Management Study for the City of Phoenix (Black & Veatch/Carollo, 2008), two contract biosolids haulers were contacted for trending and long-term outlook purposes – Synagro and Solid Motion. Synagro, the primary contract land applicator for the City of Phoenix, had been land applying the majority of biosolids generated from the 91st Avenue WWTP and the 23rd Avenue WWTP. Synagro and Solid Motion concurred in a long-term outlook identifying the need to diversify away from a Class B product in order to maintain a viable land application program in the long-term. Both contractors are proponents of producing an Exceptional Quality or Class A dried biosolids product, in order to open up new markets and allow continued land application to existing sites.

5.3 Trends Summary

In general, there are no indications in the short-term that would indicate an urgent need to take the existing level of biosolids treatment beyond Class B quality. In the long-term, production of Exceptional Quality or Class A biosolids can provide an improved degree of flexibility for biosolids disposal given the trends of reduced availability of cropland areas and increased concerns from the general public. However, a detailed analysis of disposal alternatives is recommended before embarking on investments towards the production of Class A or Exceptional Quality biosolids, in order to analyze the cost-benefits of the increased level of biosolids treatment.

6.0 CONCLUSIONS

Biosolids disposal and land application is federally regulated by the EPA 40 CFR 503. The Arizona Department of Environmental Quality (ADEQ) enforces the federal regulations and administers the biosolids program in Arizona, with oversight by the U.S. EPA.

Biosolids are classified either as Exceptional Quality, Class A, Class B, or unclassified. The higher the level of treatment to reduce pathogens and vector attraction, the less restrictions there are for beneficial reuse. Exceptional Quality and Class A biosolids may be land applied where contact with the general public is possible (i.e., nurseries, gardens, golf courses, etc.). Class B biosolids, however, may only be applied where there is no possibility of contact with the general public (i.e. certain types of agriculture, landfill, etc.). Unclassified biosolids must be disposed of in landfills.

Solids handling and treatment facilities at the Sundog WWTP include waste activated sludge (WAS) thickening, anaerobic digestion of combined primary sludge and thickened WAS, and dewatering of stabilized biosolids. The resulting Class B biosolids are disposed of via land application.

The current solids handling practice at the Airport WRF is dewatering undigested sludge, followed by landfill disposal.

The overall unit cost for biosolids management at the Airport WRF is higher than the costs at the Sundog WWTP. The main reason for this difference is the higher disposal cost associated with the Airport WRF sludge, since the Airport WRF produces unclassified biosolids, which must be disposed of via landfill. The City's current biosolids transport and disposal contract establishes a landfill disposal cost 59 percent higher than disposal to land application sites

Most facilities in Arizona produce either Class B or unclassified biosolids, with only a few facilities producing Exceptional Quality or Class A biosolids.

In the short term, there are no apparent land availability issues for Class B biosolids produced from the City. However, in the long-term the City may consider diversifying the level of biosolids treatment to respond to general trends in reduced land availability and increasing concerns by the general public.

There are no regulatory issues in the horizon that would significantly affect biosolids management in the short and medium term. However, the potential risks posed by of micro constituents and emerging contaminants are currently being evaluated at the research level.

APPENDIX A

BIOSOLIDS QUALITY AND REGULATION BACKGROUND

BIOSOLIDS QUALITY AND REGULATION BACKGROUND

A.1 PATHOGEN REDUCTION

The 40 CFR 503 regulations classify biosolids as Class A, Class B or Exceptional Quality (EQ) according to the level of treatment provided to reduce pathogens and vector attraction, and metals concentrations. EQ and Class A biosolids must undergo treatment to reduce pathogen levels to below detectable limits, whereas Class B biosolids must simply undergo pathogen reduction. To meet the requirements of EQ, the biosolids must meet more stringent metals concentrations than Class A biosolids. As the treatment requirements associated with Class B are less stringent than EQ and Class A, the options for disposal of Class B biosolids are more limited. This section will outline the various options and alternatives for pathogen and vector reduction associated with EQ, Class A, and Class B biosolids.

A.2 PATHOGEN REDUCTION FOR EXCEPTIONAL QUALITY AND CLASS A BIOSOLIDS

EQ and Class A biosolids must undergo stringent treatment for pathogen reduction to decrease the pathogen level to below detectable limits. Due to the stringent treatment requirements, EQ and Class A biosolids provide more disposal and application opportunities than their Class B counterparts. Biosolids that meet the standards for EQ and Class A pathogen reduction can be land applied at sites where contact with the general public is possible, such as parks, golf courses, and gardens. In order to meet EQ and Class A criteria, biosolids must undergo one of the alternatives for pathogen reduction listed in Table A.1.

Table A.1 Six Alternatives for Meeting EQ and Class A Pathogen Requirements
Biosolids Master Plan
City of Prescott

Alternatives[1]	Requirements
Alternative 1: Thermally Treated Biosolids	Biosolids must be subjected to one of four time-temperature regimes.
Alternative 2: Biosolids Treated in High pH-High Temperature Process	Biosolids must meet specific pH, temperature, and air-drying requirements.
Alternative 3: Biosolids Treated in Other Processes	Demonstrate that the process can reduce enteric viruses and viable helminth ova. Maintain operating conditions used in the demonstration after pathogen reduction demonstration is completed.

Table A.1 **Six Alternatives for Meeting EQ and Class A Pathogen Requirements Biosolids Master Plan City of Prescott**	
Alternatives[1]	**Requirements**
Alternative 4: Biosolids Treated in Unknown Processes	Biosolids must be tested for pathogens - *Salmonella* sp. or fecal coliform bacteria, enteric viruses, and viable helminth ova - at the time the biosolids are used or disposed, or prepared for use or disposal.
Alternative 5: Biosolids Treated in a Process to Further Reduce Pathogens (PFRP)	Biosolids must be treated in one of the PFRPs (see Table A.2).
Alternative 6: Biosolids Treated in a Process Equivalent to a PFRP	Biosolids must be treated in a process equivalent to one of the PFRPs, as determined by the permitting authority.
Note: (1) Alternatives are defined in greater detail in 40 CFR 503.	

To meet the requirements of pathogen reduction via Alternative 5, the biosolids must undergo one of the treatment technologies known as the Processes to Further Reduce Pathogens (PFRP) listed in Table A.2.

Table A.2 **Processes to Further Reduce Pathogens (PFRPs) Biosolids Master Plan City of Prescott**	
Process[1]	**Definition**
Composting	Using either the within-vessel or the static aerated pile composting method, the temperature of the biosolids is maintained at 55° C or higher for 3 days. Using the windrow composting method, the temperature of the biosolids is maintained at 55° C or higher for 15 days or longer. During the period when the compost is maintained at 55° C or higher, the windrow is turned a minimum of 5 times.
Heat Drying	Biosolids are dried by direct or indirect contact with hot gases to reduce the moisture content of the biosolids to 10% or lower. Either the temperature of the biosolids particles exceeds 80° C or the wet bulb temperature of the gas in contact with the biosolids as the biosolids leave the dryer exceeds 80° C.
Heat Treatment	Liquid biosolids are heated to a temperature of 180° C or higher for 30 minutes.
Thermophilic Aerobic Digestion	Liquid biosolids are agitated with air or oxygen to maintain aerobic conditions, and the mean cell residence time of the biosolids is 10 days at 55° to 60° C.
Beta Ray Irradiation	Biosolids are irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature.

Table A.2 Processes to Further Reduce Pathogens (PFRPs) Biosolids Master Plan City of Prescott	
Process[1]	**Definition**
Gamma Ray Irradiation	Biosolids are irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature.
Pasteurization	The temperature of the biosolids is maintained at 70° C or higher for 30 minutes or longer.
Note: (1) Treatment processes are defined in detail in 40 CFR 503.	

A.3 PATHOGEN REDUCTION FOR CLASS B BIOSOLIDS

Unlike EQ and Class A biosolids, in which pathogen levels are required to be below detectable limits, Class B requirements simply mandate a reduction in the amount of pathogens. Consequently, Class B biosolids may still contain some level of pathogens. Due to these less stringent treatment requirements, Class B biosolids are more restricted in terms of acceptable land application sites. Class B biosolids may only be applied at sites where there is no possibility of contact with the general public. In addition, Class B requirements for land application of biosolids also include site restrictions that prevent crop harvesting, animal grazing, and public access for a defined period of time after application until environmental conditions have further reduced pathogens. These site restrictions are summarized in Table A.3.

Table A.3 Site Restrictions for Class B Biosolids Land Application Biosolids Master Plan City of Prescott	
Type/Use of Crop	**Restriction[1]**
Food Crops with Harvested Parts That Touch the Biosolids/Soil Mixture	Shall not be harvested for **14 months** after application of biosolids.
Food Crops with Harvested Parts Below the Land Surface	Shall not be harvested for **20 months** after application of biosolids when the biosolids remain on the land surface for **4 months or longer** prior to incorporation into the soil. Shall not be harvested for **38 months** after application of biosolids when the biosolids remain on the land surface for **less than 4 months** prior to incorporation into the soil.
Food Crops with Harvested Parts That Do Not Touch the Biosolids/Soil Mixture, Feed Crops, and Fiber Crops	Shall not be harvested for **30 days** after application of biosolids.

Table A.3 Site Restrictions for Class B Biosolids Land Application Biosolids Master Plan City of Prescott	
Type/Use of Crop	**Restriction[1]**
Animal Grazing	Animals shall not be grazed on the land for **30 days** after application of biosolids.
Turf Growing	Shall not be harvested for **1 year** after application of the biosolids when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.
Public Access	Public access to land with a **high potential** for public exposure shall be restricted for **1 year** after application of biosolids. Public access to land with a **low potential** for public exposure shall be restricted for **30 days** after application of biosolids.

Note:
(1) These restrictions are defined in greater detail in 40 CFR 503.

Class B pathogen reduction requirements may be met through one of the three alternatives outlined in Table A.4.

Table A.4 Three Alternatives for Meeting Class B Pathogen Requirements Biosolids Master Plan City of Prescott	
Alternatives[1]	**Requirements**
Alternative 1: The Monitoring of Indicator Organisms	Test for fecal coliform density as an indicator for all pathogens. The geometric mean of seven samples shall be less than 2 million MPNs per gram per total solids or less than 2 million colony forming units (CFUs) per gram of total solids at the time of use or disposal.
Alternative 2: Biosolids Treated in a Process to Significantly Reduce Pathogens (PSRP)	Biosolids must be treated in one of the PSRPs (see Table A.5).
Alternative 3: Biosolids Treated in a Process Equivalent to a PSRP	Biosolids must be treated in a process equivalent to one of the PSRPs, as determined by the permitting authority.

Note:
(1) These alternatives are defined in greater detail in 40 CFR 503.

To meet the requirements for Class B pathogen requirements through Alternative 2, the biosolids must be treated using one of the treatment technologies known as the Processes to Significantly Reduce Pathogens (PSRP) as outlined in Table A.5.

Table A.5 Processes to Significantly Reduce Pathogens (PSRPs)
Biosolids Master Plan
City of Prescott

Process(1)	Definition
Aerobic Digestion	Biosolids are agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20° C and 60 days at 15° C.
Air Drying	Biosolids are dried on sand beds or on paved or unpaved basins. The biosolids dry for a minimum of 3 months. During 2 of the 3 months, the ambient average daily temperature is above 0° C.
Anaerobic Digestion	Biosolids are treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35-55° C and 60 days at 20° C.
Composting	Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the biosolids is raised to 40° C or higher and maintained for a 5-day period. The temperature in the compost pile must exceed 55° C.
Lime Stabilization	Sufficient lime is added to the biosolids to raise the pH of the biosolids to 12 for 2 hours of contact.

Note:
(1) The treatment processes are defined in detail in 40 CFR 503.

A.4 VECTOR ATTRACTION REDUCTION

In addition to reducing pathogen levels, EQ, Class A, and Class B requirements mandate that biosolids must undergo treatment to reduce the risk that pathogens can be transmitted via vectors such as flies, mosquitoes, fleas, rodents, and birds. The options outlined in Table A.6 achieve vector attraction reduction through either reducing the attractiveness of biosolids to vectors or preventing vectors from coming into contact with the biosolids. In order to qualify as EQ biosolids, one of the first eight vector attraction reduction options in Table A.6 must be implemented, while any of the twelve options may be utilized to achieve Class A or Class B biosolids. Note that some of these options may be achieved concurrently using the mechanisms outlined for pathogen reduction.

Table A.6	Options for Meeting Vector Attraction Reduction Biosolids Master Plan City of Prescott
Options	**Requirements[1]**
Option 1	Meet 38 percent reduction in volatile solids content.
Option 2	Demonstrate vector attraction reduction with additional anaerobic digestion in a bench-scale unit.
Option 3	Demonstrate vector attraction reduction with additional aerobic digestion in a bench-scale unit.
Option 4	Meet a specific oxygen uptake rate (SOUR) for aerobically digested biosolids.
Option 5	Use aerobic processes at greater than 40° C for 14 days or longer.
Option 6	Alkali addition under specified conditions.
Option 7	Dry biosolids with no unstabilized solids to at least 75 percent solids.
Option 8	Dry biosolids with unstabilized solids to at least 90 percent solids.
Option 9	Inject biosolids beneath the soil surface.
Option 10	Incorporate biosolids into the soil within 6 hours of application to or placement on the land.
Option 11	Cover biosolids placed on a surface disposal site with soil or other material at the end of each operating day (for surface disposal only).
Option 12	Alkaline treatment of domestic septage to pH 12 or above for 30 minutes without adding more alkaline material.

Note:
(1) The treatment processes are defined in detail in 40 CFR 503.

A.5 POLLUTANT CONCENTRATION LIMITS

In addition to meeting pathogen and vector attraction reduction requirements, biosolids must also meet heavy metal pollutant concentration limits. All biosolids (EQ, Class A, and Class B) must meet the Ceiling Concentration Limits. The Ceiling Concentration Limits are the maximum concentration limits allowed for 10 heavy metals which can occur in biosolids, including arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. The values for the Ceiling Concentration Limits are presented in Table A.7. In addition, for biosolids to qualify as EQ, they must meet the Pollutant Concentration Limits presented in Table A.7. The Pollutant Concentration Limits are more stringent heavy metal pollutant concentration levels than the Ceiling Concentration Limits. Both the Pollutant and Ceiling Concentration Limits are based on dry weight.

Table A.7 Pollutant Limits for Biosolids Biosolids Master Plan City of Prescott		
Pollutant	**Ceiling Concentration Limits (mg/kg) (1)**	**Pollutant Concentration Limits (mg/kg) (1)**
Arsenic	75	41
Cadmium	85	39
Chromium	3,000	1,200
Copper	4,300	1,500
Lead	840	300
Mercury	57	17
Molybdenum	75	-
Nickel	420	420
Selenium	100	36
Zinc	7,500	2,800
Note: (1) The pollutant limits are defined in detail in 40 CFR 503.		

APPENDIX B

EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS

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EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS
SUNDOG WWTP

Project: Prescott Airport and Sundog WRF Technology Assessments — Updated: 3/22/2010
Job #: 8286A.00
Location: Prescott, Az
Zip Code: 86301

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**Annual Energy Costs**					
	Waste Activated Sludge Thickening	59,881	kW-hr	0.086	5,150	$5,150
	Anaerobic Digestion	179,642	kW-hr	0.086	15,449	$15,449
	Dewatering	21,094	kW-hr	0.086	1,814	$1,814
	Natural gas heating	18,000	therms	1.060	19,080	$19,080
					ANNUAL POWER COST SUBTOTAL	***$41,493***
2	**Annual Chemical Costs**					
	Polymer, dry	14,000	lb	1.73	24,220	$24,220
					ANNUAL CHEMICAL COST SUBTOTAL	***$24,220***
3	**Annual Biosolids Disposal Costs**					
	Transport and Disposal - Land Application	2,932	wet ton	29.5	86,492	$86,492
	Transport and Disposal - Landfill	402	wet ton	47.0	18,902	$18,902
					ANNUAL DISPOSAL SUBTOTAL	***$105,394***
4	**Annual Miscellaneous Costs**					
	Fecal Coliform Testing	68	test	26	1,768	$1,768
	Biosolids Analysis	4	test	301	1,204	$1,204
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$2,972***
					ANNUAL O&M TOTAL	***$174,079***

EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS
ENERGY CONSUMPTION CALCULATIONS
SUNDOG WWTP

Item No.	Description	Total # units	# running	HP, each	HP running	kW running	Hours/day	Hours/Year	kW-hr /yr
1	**Waste Activated Sludge Thickening**								
	WAS pumps to Gravity Belt Thickener	2	1	5.0	5	3.7	24	8,760	32,662
	Gravity Belt Thickener	2	1	1.0	1	0.7	24	8,760	6,532
	Thickened WAS pumps to digesters	2	2	5.0	10	7.5	4	1,460	10,887
	Polymer feed pumps	1	1	1.5	1.5	1.1	24	8,760	9,799
								TOTAL	***59,881***
2	**Anaerobic Digestion**								
	Anaerobic digester draft tube mixers (primary dig)	4	4	5.0	20	14.9	24	8,760	130,649
	Digested sludge recirculation pumps	3	1	7.5	7.5	5.6	24	8,760	48,993
								TOTAL	***179,642***
3	**Dewatering**								
	Digested sludge pumps to belt press	1	1	7.5	7.5	5.6	5	1,825	10,207
	Washwater booster pump for belt press	1	1	3.0	3	2.2	5	1,825	4,083
	Belt dewatering press	1	1	5.0	5	3.7	5	1,825	6,805
								TOTAL	***21,094***

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EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS
AIRPORT WRF

Project: Prescott Airport and Sundog WRF Technology Assessments — Updated: 3/22/2010
Job #: 8286A.00
Location: Prescott, Az
Zip Code: 86301

Item No.	Description	Unit Qty.	Std. Unit	Unit Price	Item Total	Total Cost
1	**Annual Energy Costs**					
	Solids Storage and Thickening	69,407	kW-hr	0.086	5,969	$5,969
	Sludge Dewatering	151,199	kW-hr	0.086	13,003	$13,003
	Propane gas heating	1,350	unit	1.600	2,160	$2,160
					ANNUAL POWER COST SUBTOTAL	***$21,132***
2	**Annual Chemical Costs**					
	Polymer, dry	30,500	lb	1.03	31,415	$31,415
					ANNUAL CHEMICAL COST SUBTOTAL	***$31,415***
3	**Annual Biosolids Disposal Costs**					
	Transport and Disposal - Land Application	127	wet ton	29.5	3,748	$3,748
	Transport and Disposal - Landfill	1,032	wet ton	47.0	48,488	$48,488
					ANNUAL DISPOSAL SUBTOTAL	***$52,235***
4	**Annual Miscellaneous Costs**					
	Biosolids Analysis	1	test	301	301	$301
					ANNUAL MISCELLANEOUS COST SUBTOTAL	***$301***
					ANNUAL O&M TOTAL	***$105,083***

EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS
ENERGY CONSUMPTION CALCULATIONS
AIRPORT WRF

Item No.	Description	Total # units	# running	HP, each	HP running	kW running	Hours/day	Hours/Year	kW-hr /yr
1	**Solids Storage and Thickening**								
	Solids storage basin aeration blower	1	1	15.0	15	11.2	15	5,475	61,242
	Thickened WAS pumps in solids storage basin	2	1	3.0	3	2.2	10	3,650	8,166
								TOTAL	***69,407***
2	**Sludge Dewatering**								
	Sludge grinder	2	1	5.0	5	3.7	10	3,650	13,609
	Centrifuge feed pump	1	1	7.5	7.5	5.6	10	3,650	20,414
	Dewatering centrifuge	1	1	30.0	30	22.4	10	3,650	81,655
	Dewatering centrifuge auger	1	1	3.0	3	2.2	10	3,650	8,166
	Centrifuge Hydraulic Pump	1	1	10.0	10	7.5	10	3,650	27,218
	Polymer feed pump	1	1	0.1	0.05	0.0	10	3,650	136
								TOTAL	***151,199***

EXISTING BIOSOLIDS MANAGEMENT PROGRAM COSTS
Biosolids Disposal Costs

Land Application: 29.5 $/wet ton
Landfill Disposal: 47.0 $/wet ton

	Wet tons produced			*Disposal Costs*			
	Sundog	Airport	Total	Sundog	Airport	Total	
	195.9	96.6	292.4	9,206	4,538	13,744	
	301.5	96.6	398.0	12,504	4,005	16,508	
	392.5	96.6	489.0	11,578	2,848	14,426	
	437.1	61.5	498.5	12,893	2,889	15,782	
	360.6	95.4	456.0	10,638	4,483	15,121	
	226.9	86.8	313.7	6,694	4,078	10,772	
	278.2	95.3	373.5	8,208	4,478	12,686	
	237.0	139.1	376.1	6,991	6,539	13,530	
	199.9	103.5	303.4	5,897	4,863	10,760	
	187.5	91.2	278.6	5,530	4,286	9,816	
	213.6	75.3	288.8	6,300	3,538	9,837	
	303.6	121.1	424.7	8,956	5,691	14,647	
	3,334.1	1,158.7	4,492.8	105,394	52,235	**157,629**	
Land app:	2,931.9	127.0	3,059.0	86,492	3,748	90,240	90,240
Landfill:	402.2	1,031.7	1,433.8	18,902	48,488	67,390	67,390
Total	3,334.1	1,158.7	4,492.8	105,394	52,235	**157,629**	**157,629**

City of Prescott
Sundog WWTP and Airport WRF
Capacity and Technology Master Plan

Technical Memorandum No. 9
Biosolids Alternatives Evaluation

Final

In Association with

Project No. 164890

3133 E. Camelback Rd • SUITE 210 • PHOENIX, ARIZONA 85016 • (602) 381-4400 • FAX (602) 381-4440

City of Prescott

TECHNICAL MEMORANDUM
NO. 9
BIOSOLIDS ALTERNATIVES EVALUATION

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ES9 TM 9 – BIOSOLIDS ALTERNATIVES EVALUATION

ES9.1 Introduction

The long-term capital improvements identified for the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF) include the expansion of the treatment facilities and supporting infrastructure. These expansions will result in the generation of additional biosolids requiring treatment and disposal. The increased quantities of biosolids will present new biosolids treatment and disposal challenges, which will directly impact treatment plant operations and budgeting efforts. The City has recognized the need to review and evaluate their approach to biosolids management procedures to provide a framework for future treatment and disposal practices. Furthermore, the instability in legislation and market changes associated with biosolids necessitate the identification of appropriate alternatives to maximize the City's biosolids treatment and disposal flexibility in the future.

Technical Memorandum (TM) No. 9 is part of the Sundog WWTP and Airport WRF Capacity and Technology Master Plan, and addresses Task Group 1200 – Biosolids Alternatives Evaluation.

The main purposes of this TM No. 9 are:

- To review available biosolids disposal and reuse alternatives and recommend near-term and long-term disposal alternatives.
- To review and screen available biosolids stabilization alternatives, in order to select alternatives for detailed evaluation.
- To determine the facilities required for the recommended biosolids stabilization alternatives.
- To evaluate biosolids management alternatives at separate wastewater treatment facilities versus all biosolids management at a centralized treatment plant.
- To evaluate alternatives for biogas utilization.
- To perform a detailed evaluation of economic and non-economic factors for the biosolids management alternatives considered.

ES9.2 Biosolids Disposal and Reuse Alternatives

Ultimately, the desired biosolids disposal and reuse options play a significant role in the selection of the sludge stabilization processes (i.e., EQ versus Class A versus Class B) and the subsequent solids handling facilities.

The goal of this biosolids alternatives evaluation is to determine disposal options, which provide flexibility, redundancy, and the ability to meet current and future regulatory criteria. As mentioned previously, there are currently no formal restrictions for the land application of biosolids in the State of Arizona. Even though a number of counties in California have implemented full or partial bans of Class B biosolids land application and/or restrictions on the use of EQ and Class A biosolids, it is difficult to predict whether or not such restrictions would ever be imposed in Arizona.

As stated in TM No. 8, there are no clear indications that Class B land application would be restricted for the City of Prescott in the foreseeable future. Therefore, we recommend master planning biosolids treatment facilities based on achieving Class B, with considerations to achieve Class A in the future.

The following Table ES9.1 summarizes the options for biosolids disposal evaluated as part of this TM.

Table ES9.1 Biosolids Disposal Alternatives Summary
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Minimum Biosolids Criteria					
Disposal/Beneficial Reuse Alternative	**EQ**	**Class A**	**Class B**	**Liquid**	**Dewatered**	**Dry Pellets**
Land Application - Agricultural Land			X	X		
Land Application - City-owned Land(1)	X	X			X	X
Landfill Disposal(2)					X	
Commercial Product	X	X				X

Notes:

(1) Will depend on requirements of the City Parks and Recreation and Transportation Departments.

(2) Landfill disposal requires dewatering to level capable of passing the Paint Filter Test. Class B, A, or EQ can also be disposed of in landfills.

The most cost-effective and practical strategy would be for the City to continue its practice of land applying Class B biosolids from the Sundog WWTP on agricultural land, and to continue landfill disposal of biosolids from the Airport WRF until biosolids stabilization facilities can be constructed. However, landfill disposal is not recommended as a long-term alternative, as available landfill space is generally limited. Therefore, the City should plan to implement improvements at the existing Airport WRF to produce Class B biosolids when this alternative becomes economically viable. Ultimately, upgrading the stabilization processes to achieve EQ or Class A biosolids should be considered, in order to maintain the greatest flexibility with future biosolids disposal alternatives.

ES9.3 Biosolids Stabilization

The City's existing WWTPs are currently equipped with processes capable of reliably producing Class B biosolids (Sundog WWTP) or unclassified biosolids (Airport WRF), which limits available biosolids management alternatives to agricultural farmland sites and landfill disposal. Although these management strategies are sufficient and generally considered to be the most cost effective in the near- and long-term, changing regulations and decreasing availability of agricultural lands may limit opportunities for land apply and landfill in the future. As a result, the City may have to consider higher levels of treatment for biosolids production in the future, and consequently would have to add technologies (i.e. additional equipment and facilities) to the current processes in order to produce EQ or Class A biosolids.

After initial process screening, the following stabilization processes were evaluated for the Sundog WWTP and the Airport WRF as separate treatment facilities, or a centralized Airport WRF:

- Conventional Anaerobic Digestion
- Thermal Drying

The capital costs and operating costs for anaerobic digestion and thermal drying at the Sundog WWTP, Airport WRF, and the Centralized Airport WRF are provided in Tables ES9.2, ES9.3, and ES9.4 below. For all cases, anaerobic digestion is the preferred economic alternative.

Table ES9.2 Stabilization Capital and Operating Costs – Sundog WWTP
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Criteria	Anaerobic Digestion	Thermal Drying
Probable Construction Cost	$5,426,000	$14,000,000
Annual O&M Costs	$340,100	$1,220,000
Total Life-Cycle Cost	$10,099,000	$27,990,000

Note:
(1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.

Table ES9.3 Stabilization Capital and Operating Costs – Airport WRF Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Criteria	**Anaerobic Digestion**	**Thermal Drying**
Probable Construction Cost	$22,680,000	$21,700,000
Annual O&M Costs	$544,600	$2,192,000
Total Life-Cycle Cost	$30,163,000	$46,840,000
Note: (1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.		

Table ES9.4 Stabilization Capital/Operating Costs - Centralized Airport WRF Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Criteria	**Anaerobic Digestion**	**Thermal Drying**
Probable Construction Cost	$25,760,000	$35,700,000
Annual O&M Costs	$732,000	$3,362,000
Total Life-Cycle Cost	$35,818,000	$75,250,000
Note: (1) As present value, assuming life-cycle period of 20 years, interest rate of 6% and escalation rate of 2%.		

While anaerobic digesters are preferred from an economic standpoint, thermal dryers will produce a fertilizer product that has agricultural and recycling value, whereas dewatered anaerobic sludge has little value and in many jurisdictions has become a liability for municipal agencies. Given a long term view of biosolids disposal, the City of Prescott should consider thermal drying of biosolids in a central treatment facility as flows increase and new residential construction re-starts.

In considering a regional biosolids treatment facility, the following alternatives were identified for future consideration:

- Composting
- Thermal drying
- Biosolids to Energy (Incineration)

ES9.4 Biogas Utilization

As part of the biosolids master planning tasks, biogas utilization options for the Sundog WWTP and the regional treatment facility alternative at Airport WRF were evaluated. The biogas utilization options considered in this evaluation include process heating and on-site power generation. Economic and non-economic considerations and life cycle costing were used to evaluate potential biogas utilization alternatives.

Biogas produced through anaerobic digestion is a prime source of energy that is traditionally used for process heat (digestion and/or heat drying), building heat, or to generate power. Heat recovery from on-site power generation or drying can also be employed to heat digesters and buildings. The costs and benefits of biogas utilization vary depending on capacity requirements, purchased energy costs, biogas cleaning requirements, and process heat requirements. Three biogas utilization options were short-listed for detailed evaluation for each treatment facility, as follows:

1. Biogas use for process (anaerobic digester) heat.
2. Biogas use in engine generators for on-site power generation and waste heat recovery.
3. Biogas use in MicroTurbines for on-site power generation and waste heat recovery.

Equipment requirements and costs were developed for each alternative at both the Sundog WWTP and the centralized treatment facility at the Airport WRF. In addition, costs were developed for a “base case” scenario. The “base case” scenario represents no energy recovery and flaring of all biogas. Natural gas must be purchased for digester heating in the “base case” scenario.

Descriptions of each evaluated alternative for power generation and energy recovery are presented below:

- Case 1 - All biogas to the boiler for digester heating. Excess biogas is flared. This configuration is widely used at WWTPs equipped with anaerobic digestion.
- Case 2 - All gas to engine generators. Heat recovered from the engine generator jackets and exhaust is used for digester heating.
- Case 3 - All gas to MicroTurbines. Heat recovered from the MicroTurbine exhaust is used for digester heating.

Sundog WWTP

The following Table ES9.5 summarizes the cost or savings associated with each scenario described above for the Sundog WWTP.

Table ES9.5 Costs and Benefits for Digester Gas Utilization at Sundog WWTP Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
	Case 1 Digester Heat	**Case 2 Engine Generators**	**Case 3 MicroTurbines**
Capital Cost, $			
Energy recovery	0	337,000	532,000
Gas cleaning	200,000	693,000	808,000
Total	200,000	1,030,000	1,340,000
Annual Costs for Energy Recovery, $/year			
Electricity	0	0	0
Labor	0	21,000	19,000
Maintenance materials	0	16,000	6,000
Total	0	37,000	25,000
Annual Costs for Gas Cleaning, $/year			
Electricity	13,000	14,000	24,000
Labor	6,000	23,000	23,000
Maintenance materials	1,000	18,000	18,000
Total	20,000	55,000	65,000
Annual Benefits, $/year			
Electricity (Savings)	0	(89,000)	(66,000)
Natural Gas (Savings)	(33,000)	(33,000)	(32,000)
Present Worth Costs, $			
Capital Costs	200,000	1,030,000	1,340,000
Annual Costs	20,000	92,000	90,000
Annual (Savings)	(33,000)	(122,000)	(98,000)
Total Annual Cost (Savings)	(13,000)	(30,000)	(8,000)
PW Annual Cost (Savings)	(162,000)	(374,000)	(100,000)
PW Total Cost (Savings)	38,000	656,000	1,240,000
Annualized PW Cost	3,000	53,000	100,000

Life cycle costs evaluation for the Sundog WWTP shows that the total present worth cost of the three biogas utilization alternatives are $38,000, $656,000, and $1,240,000, respectively, meaning that no cost savings are projected. Based on the results of this evaluation, on-site power generation is not cost effective and is therefore not recommended for the Sundog WWTP. However, use of biogas for digester heating eliminates the need for natural gas purchases and consequently, the impacts of fluctuating natural gas prices on plant O&M costs. There is considerable potential savings with this approach, particularly if biogas treatment is not required. In fact, the City reports that by switching to untreated digester gas for sludge heating, they are currently saving about $63,000 per year.

Centralized Airport WRF

Table ES9.6 summarizes the cost benefits of each scenario described above for a Centralized Airport WRF.

Table ES9.6 Costs and Benefits for Digester Gas Utilization at Centralized Airport WRF
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Case 1 Digester Heat	Case 2 Engine Generators	Case 3 MicroTurbines
Capital Cost, $			
Energy recovery	0	676,000	8611,000
Gas cleaning	530,000	894,000	1,049,000
Total	530,000	1,570,000	1,860,000
Annual Costs for Energy Recovery, $/year			
Electricity	0	0	0
Labor	0	25,000	20,000
Maintenance materials	0	35,000	14,000
Total	0	60,000	34,000
Annual Costs for Gas Cleaning, $/year			
Electricity	14,000	16,000	28,000
Labor	6,000	23,000	23,000
Maintenance materials	2,000	36,000	37,000
Total	22,000	75,000	88,000
Annual Benefits, $/year			
Electricity	0	(200,000)	(148,000)
Natural Gas Savings	(74,000)	(74,000)	(71,000)
Present Worth Costs, $			
Capital Costs	530,000	1,570,000	1,860,000
Annual Costs	22,000	135,000	125,000
Annual Savings	(74,000)	(274,000)	(219,000)
Total Annual Cost (Savings)	(52,000)	(139,000)	(97,000)
PW Annual Cost (Savings)	(648,000)	(1,732,000)	(1,208,000)
PW Total Cost (Savings)	(118,000)	(162,000)	652,000
Annualized PW (Savings)	(9,000)	(13,000)	52,000

Based on the lifecycle costs of the gas utilization options at the Centralized Airport WRF, on-site power generation using engine generators may be cost effective. As shown in Table ES9.6, the present worth savings for the Cases 1 and 2 are $118,000 and $162,000 respectively, and the present worth cost for Case 3 is $652,000. Based on the results of this evaluation, on-site power generation using engine generators is recommended for future consideration at a Centralized Airport WRF when the capital cost of the facilities is not constrained by funds availability in the City's CIP. If future emission restrictions at the Centralized Airport WRF require advanced emission control for engine generators, Case 2 capital and O&M costs will increase significantly and the evaluation should be revisited.

ES9.5 Regional Biosolids Management

As part of this project, the team discussed the possibilities/opportunities for a regional biosolids handling facility, which could process and provide beneficial end use of biosolids from a variety of surrounding communities, including the City of Prescott. In the context of a larger regional facility, the potential application of certain technologies becomes significantly more viable as capital and O&M costs can be partially offset by factors including economies of scale and cogeneration opportunities.

Contributing communities could share the fiscal responsibility for construction and operation, thereby reducing the burden on the individual communities. In addition, the resulting high quality biosolids could be redistributed within the participating communities on community-owned parks and golf courses, or could potentially be marketed to outside agencies or the general public - providing a sustainable market for the beneficial end use product. Based on these factors, the possibility of a regional biosolids handling facility was evaluated, on a cursory level, as a potential long-term biosolids management strategy.

The successful implementation of a regional biosolids handling facility would depend heavily on the collaboration of various organizations, governing authorities, and local communities. Each group would play a significant role in the coordination of the project. Currently four of the local communities outside of Prescott have expressed interest in a regional biosolids handling facility project. Without the commitment of a majority of the communities to treat their undigested sludge at the regional facility, implementation of the facility may not be economically justifiable. Table ES9.7 provides a summary of the various communities contacted during this evaluation, their current and anticipated solids production as well as the general interest in a regional facility.

Table ES9.7 Summary of Potential Regional Facility Community Participants Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona				
Community	**Current Biosolids Management Practice**	**Current Biosolids Production (wet tons/ year)**	**Estimated Future Biosolids Production (wet tons/year)**	**Potential Interest in Regional Facility?**
City of Flagstaff	Subsurface injection Class B biosolids	1,000 [(1)]	N.A.	Yes
City of Sedona	Landfill dewatered sludge	1,500	2,500	Yes
Town of Prescott Valley	Landfill Class B biosolids	4,500 - 5,000	15,000	Yes
Town of Camp Verde	Landfill dewatered sludge	N.A.	N.A.	Yes
Town of Chino Valley	Landfill dewatered sludge	274	1,100	N.A.
Town of Clarkdale	Landfill disposal of lagoon sludge	N.A.	N.A.	N.A.
City of Prescott	Land application Class B biosolids, and landfill dewatered sludge	4,490	21,800	Yes
Notes: (1) To be confirmed N.A. = Not available at the time the report was issued.				

ES9.6 Conclusions

ES9.6.1 Biosolids Disposal and Reuse

The City currently practices land application on agricultural land with Class B biosolids from the Sundog WWTP. Unclassified biosolids from the Airport WRF are currently disposed of at a landfill. Maintaining these disposal and reuse practices represents the most cost-effective near-term strategy for the City. In the long-term, landfill disposal costs may increase and it will likely be cost effective to implement Class B biosolids stabilization facilities at the Airport WRF. If hauling costs increase dramatically, alternatives that significantly reduce the volume for disposal/reuse, such as thermal drying or biosolids-to-energy may become viable.

ES9.6.2 Biosolids Stabilization

For the near-term and long-term, continued anaerobic digestion is recommended for the Sundog WWTP. At the Airport WRF, continued dewatering and hauling of non-stabilized solids is recommended in the near-term. As the Airport WRF grows in size (5-10 mgd) and the costs for landfilling of unclassified biosolids increases, it is recommended that the City implement anaerobic digestion for Class B biosolids stabilization. If centralized treatment at the Airport WRF is implemented, anaerobic digestion is recommended for the near-term and long-term to achieve Class B biosolids. Should a regional biosolids facility becomes a reality, alternatives to achieve Class A biosolids such as composting, thermal drying, and biosolids-to-energy should be evaluated.

ES9.6.3 Biogas Utilization

Continued use of biogas for digester heating at the Sundog WWTP is recommended. The City reports that they are saving approximately $63,000 per year in operating costs by eliminating natural gas heating of the digesters. Currently, on-site power generation is not cost-effective at the Sundog WWTP, unless grants or subsidies are available. If centralized treatment at the Airport WRF is implemented, on-site power generation will likely be cost effective when the treatment plant wastewater flow reaches approximately 5 mgd. Finally, if electrical power costs increase significantly, on-site power generation should be further evaluated for the Sundog WWTP or the Airport WRF (when anaerobic digestion is implemented at that facility).

ES9.6.4 Regional Biosolids Management

There does not appear to be an immediate opportunity for regional biosolids management given the need for significant collaboration between multiple organizations. The City should maintain contact with potential partners in the region, to determine if a regional biosolids facility would be practical and economical in the long-term. There may also be potential public-private partnership opportunities in the future with a regional solution to biosolids management.

1.0 INTRODUCTION

The long-term capital improvements identified for the Sundog Wastewater Treatment Plant (WWTP) and the Airport Water Reclamation Facility (WRF) include the expansion of the treatment facilities and supporting infrastructure. These expansions will result in the generation of additional biosolids requiring treatment and disposal. The increased quantities of biosolids will present new biosolids treatment and disposal challenges, which will directly impact treatment plant operations and budgeting efforts. The City has recognized the need to review and evaluate their approach to biosolids management procedures to provide a framework for future treatment and disposal practices. Furthermore, the instability in legislation and market changes associated with biosolids necessitate the establishment of appropriate alternatives to maximize the City's biosolids treatment and disposal flexibility in the future.

Technical Memorandum (TM) No. 9 is part of the Sundog WWTP and Airport WRF Capacity and Technology Master Plan, and addresses Task Group 1200 – Biosolids Alternatives Evaluation.

The main objectives of this TM No. 9 are:

- To review available biosolids disposal alternatives to identify the recommended long term disposal alternative.
- To review and screen available biosolids stabilization alternatives, in order to select alternatives for detailed evaluation.
- To determine the facilities required for the recommended biosolids stabilization alternatives.
- To evaluate biosolids management alternatives at separate wastewater treatment facilities versus all biosolids management at one plant.
- To identify alternatives for sludge gas utilization.
- To perform a detailed evaluation of economic and non-economic factors for the biosolids management alternatives considered.

2.0 BIOSOLIDS DISPOSAL ALTERNATIVES

Ultimately, the desired biosolids disposal options play a significant role in the selection of the sludge stabilization processes (i.e., EQ versus Class A versus Class B) as well as the subsequent solids handling facilities (i.e., the necessity for mechanical dewatering). Consequently, it is important to introduce potential alternatives as part of this evaluation to ensure that the selection of the desired sludge stabilization process is made with consideration for all applicable factors.

The ultimate goal of the Biosolids Master Plan is to determine disposal options, which provide flexibility, redundancy, and the ability to meet current and future regulatory criteria. As mentioned previously, there are currently no formal restrictions for the land application of biosolids in the State of Arizona. Even though a number of counties in California have implemented full or partial bans of Class B biosolids land application and/or restrictions on the use of EQ and Class A biosolids, it is difficult to predict whether or not such restrictions would ever be imposed in Arizona.

As stated in Technical Memorandum No. 8, there are no clear indications that Class B land application would be restricted for the City of Prescott in the foreseeable future. Therefore, we recommend master planning biosolids treatment facilities based on achieving Class B, with considerations to achieve Class A in the future. The subsequent sections outline the possible disposal and/or reuse options considered as part of this Biosolids Management Plan.

2.1 Land Application on Agricultural Lands

Land application is the injection and/or spreading and incorporating of biosolids onto land used for agricultural or horticultural purposes. Biosolids can enhance soil characteristics by improving tillage, porosity, and moisture retention. For these reasons, land application of biosolids is considered a beneficial use. Biosolids from the Sundog WWTP are currently being land applied in local agricultural through a third party contractor. The requirements for both land application alternatives are discussed herein.

This form of biosolids disposal is the City's current practice. A contract is established between the biosolids generator (City) and a land applier, who in turn, establishes an agreement with local agricultural landowners. The terms of the contract can vary depending on the situation. However, most contracts include terms for biosolids hauling and land application services. Regulations allow the land application of all classes of biosolids. However, restrictions on land use (mainly involving public access), crop harvesting, and animal grazing vary depending on the classification of the biosolids. Land application restrictions are more stringent for Class B biosolids, as opposed to EQ and Class A biosolids. Consequently, treatment requirements for Class B biosolids are not as stringent as those for EQ and Class A biosolids.

2.1.1 Advantages

- Does not require the City to own and operate hauling and spreading equipment, biosolids storage facilities, or application sites.
- Does not require the City to maintain required bookkeeping and submit application data to the regulators.
- The City already produces Class B biosolids from the Sundog WWTP, and therefore this option provides familiarity with operations staff for both the stabilization and disposal process requirements.

2.1.2 Disadvantages

- The City is not benefiting from beneficial reuse characteristics of biosolids.
- In the long-term, continued growth of urban areas may convert agricultural land use to residential use, thereby decreasing available area for land application.
- Hauling costs are often based on distance, and can vary with dynamic fuel prices. Rising fuel prices may result in land application in outlying areas becoming cost prohibitive.
- Most biosolids hauling and application companies have agreements with other municipalities. If contamination problems arose at the associated disposal site, the City could assume shared liability.
- The City has little or no control over increases in contract hauling and applying services costs. In effect, the City is at the “mercy” of local market conditions, and is “competing” for available land application with adjacent communities following similar practices.

2.1.3 Summary of Land Application on Agricultural Lands

At the present time, maintaining the City’s current practices is the most cost effective near-term strategy, as it would not require any capital improvements beyond the planned WRP expansions. However, as discussed previously, this alternative may not provide the most reliable long-term strategy for the City.

2.2 Land Application on City-Owned Land

Another potential biosolids reuse option available to the City is land application on City-owned land, specifically land managed by the City’s Park and Streets Departments. Under this option, the City would serve in the roles of the biosolids generator, hauler, and applicator. This alternative requires the City's wastewater treatment facilities generate either EQ or Class A biosolids since land application on City-owned properties yields the potential opportunity for public contact with the biosolids.

2.2.1 Advantages

- The City directly benefits from the beneficial characteristics of the biosolids.
- Annual hauling and disposal costs would be offset by discontinuing the purchase of a significant portion of the fertilizer used on the City's golf courses, parks, and landscaped areas.
- Promotes cost savings and improved public services across several City departments.

2.2.2 Disadvantages

- Will require significant capital improvements at the wastewater treatment plant(s). Specifically, the sludge stabilization process will need to be upgraded in order to achieve Class A or EQ biosolids criteria.
- Available City-owned lands may not be sufficient to handle the volume of biosolids produced, meaning that this option would likely need to be coupled with one or more additional disposal options.
- Required alternative stabilization processes may generate additional operation and maintenance costs.
- This option would require that the City own and operate hauling and spreading equipment and biosolids storage facilities.
- This option would hold the City responsible for conducting the requisite sampling and submitting reports to regulators.

2.2.3 Summary of Land Application on City-Owned Lands

Land application on City-owned land would require significant capital improvements to the City's WRFs in order to achieve the necessary biosolids quality. However, this alternative may be necessary should land application on agricultural lands and landfill disposal become unavailable as a long-term possibility; or alternately could be a backup option if improvements are completed at the Sundog WWTP and/or Airport WRF to produce EQ or Class A biosolids in the future.

2.3 Landfill Disposal

If land application of Class B biosolids becomes unavailable, another potential biosolids management alternative involves transporting the City's biosolids to a local landfill for disposal. The City of Prescott currently uses this disposal alternative for biosolids from the Airport WRF.

In order to meet the requirements for landfill disposal, the biosolids must be dewatered to a level capable of passing the Paint Filter Test to comply with 40 CFR 264. The Paint Filter Test is used to determine the presence of free liquids in a representative sample of waste. During this test, a predetermined sample of waste is placed on a paint filter, and if a portion of the sample passes through and drops from the filter, the sample is deemed to contain free liquids, and therefore, does not pass the test.

Although not specifically identified as a separate alternative herein, another possible method of biosolids disposal management involves transporting the City's biosolids to a local landfill for use as an alternative daily cover (ADC). This option can be implemented with varying biosolids percent solid concentrations. The biosolids are hauled to landfill sites where they are mixed with soil or other materials before being placed over disposed refuse to control refuse blowing and vector attraction. This would be considered a beneficial reuse option. However, the City would likely have to purchase and maintain their own hauling equipment, and would be responsible for requisite sampling and testing. Additional coordination with the landfill operators will be necessary to further determine the viability of this alternative.

2.3.1 Advantages

- Two local landfills currently available.
- Biosolids stabilization facilities are not required (only dewatering to 20 percent solids is required).
- Beneficial reuse option when used as an alternative daily cover.

2.3.2 Disadvantages

- The City does not directly gain from the beneficial characteristics of biosolids.
- The City would have to continue to pay for contract hauling or purchase and operate their own biosolids hauling equipment.
- Disposal (tipping) fees at landfills are typically higher in comparison to those associated with land application.
- This option would only be appropriate as a medium-term practice, as available landfill space is finite.

2.3.3 Summary of Landfill Disposal

In the long-term, this biosolids disposal alternative can be considered a backup, albeit non-beneficial reuse alternative in the event that Class B biosolids land application becomes unavailable. However, this alternative cannot be considered a long-term solution, as available landfill space is ultimately limited.

2.4 Commercial Product

Biosolids can also be stabilized, dewatered, and packaged as a commercial fertilizer and sold or given away. The 40 CFR 503 regulations for the disposal of biosolids as a commercial product require that the biosolids meet EQ or Class A biosolids criteria. In addition, biosolids to be bagged and sold must be produced in a usable form for consumers. This requires reducing the moisture content of the sludge (typically by heat drying) to form dry, dirt-like pellets. In this form, and with its neutral odor, the biosolids are more acceptable to consumers and more easily marketable as a commercial product.

2.4.1 Advantages

- Beneficial reuse option.
- Potential for the City to save on disposal costs and/or create revenue.
- Promotes good public relations.
- Potential for this option to be coupled with other disposal options.

2.4.2 Disadvantages

- Will require wastewater treatment plant process improvements. Specifically, the sludge stabilization process will need to be upgraded in order to achieve EQ or Class A biosolids criteria.
- Sludge drying equipment will be required, which can be energy intensive.
- Additional stabilization and drying processes may generate additional operation and maintenance costs.

2.4.3 Summary of Commercial Product

Treating the City's biosolids to the quality of a commercial product would be more costly than treating to that for merely land applying on City-owned land. The primary benefits to the City is that it could likely handle the volume of biosolids produced (as compared to land application on City-owned lands) and would serve as a possible form of revenue.

2.5 Biosolids Disposal Alternatives Summary

As previously mentioned, several biosolids disposal options are available to the City depending on the level of pathogen and vector attraction reduction (i.e., EQ, Class A or Class B) and the extent of dewatering. The City has the option of land applying Class B biosolids on available agricultural lands (current practice), land applying EQ or Class A biosolids on City-owned lands, disposing at a landfill (current practice), or selling/giving away as a commercial product (EQ or Class A).

Table 2.1 summarizes the minimal biosolids criteria and end-product form required for each biosolids disposal alternative evaluated. Disposal or reuse alternatives that are acceptable for Class B biosolids are also acceptable for Class A and EQ quality biosolids.

Table 2.1 Biosolids Disposal Alternatives Summary
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Disposal/Beneficial Reuse Alternative	Minimum Biosolids Criteria					
	EQ	Class A	Class B	Liquid	Dewatered	Dry Pellets
Land Application - Agricultural Land			X	X		
Land Application - City-owned Land(1)	X	X			X	X
Landfill Disposal(2)					X	
Commercial Product	X	X				X

Notes:

(1) Will depend on requirements of the City Parks and Recreation and Transportation Departments.

(2) Landfill disposal requires dewatering to level capable of passing the Paint Filter Test. Class B, A, or EQ can also be disposed of in landfills.

The previous discussions for each disposal option identified that the most cost-effective and practical strategy would be for the City to continue its practice of land applying Class B biosolids from the Sundog WWTP on agricultural land, and to continue landfill disposal of biosolids from the Airport WRF until biosolids stabilization facilities can be constructed. However, landfill disposal cannot be a long-term alternative, as available landfill space is generally limited. Therefore, as a long-term option, the City should explore the possibility of implementing improvements at the existing WRPs to produce Class B biosolids at the Airport WRF. Flexibility to upgrade stabilization processes to achieve EQ or Class A biosolids should be considered, in order to maintain the greatest flexibility with future biosolids disposal alternatives.

3.0 BIOSOLIDS STABILIZATION ALTERNATIVES SCREENING

The City's existing water reclamation plants are currently equipped with processes capable of reliably producing Class B biosolids (Sundog WWTP) or unclassified biosolids (Airport WRF), which limits available biosolids management alternatives to agricultural farmland sites and landfill disposal. Although these management strategies are sufficient and generally considered to be the most cost effective in the near- and long-term, changing regulations and decreasing available agricultural lands may limit opportunities for land application and landfill in the future. As a result, the City may have to consider higher levels of treatment for biosolids production in the future, and consequently would have to add technologies (i.e. additional equipment and facilities) to the current processes in order to produce EQ or Class A biosolids.

The following sections identify and evaluate viable sludge stabilization technology alternatives that produce Class B or higher biosolids quality. Each of the alternatives are summarized and evaluated based on various criteria, including their effectiveness in achieving the desired quality biosolids. Potential end users for the biosolids created using alternative stabilization processes are also identified.

The intent of this evaluation is to provide a comprehensive analysis of the viable sludge stabilization technologies, including the following:

- Conventional Aerobic Digestion
- Autothermal Thermophilic Aerobic Digestion (ATAD)
- Conventional Anaerobic Digestion
- Multi-Phase Anaerobic Digestion
- Temperature-Phase Anaerobic Digestion
- Thermal Treatment
- Thermal Drying
- Pasteurization
- Chemical Addition
- Composting
- Biosolids to Energy (Incineration)

3.1 Conventional Aerobic Digestion

Aerobic digestion is a suspended-growth biological treatment process that oxidizes organisms and other organic matter, which results in pathogen and solids reduction in the biosolids. Oxidation is achieved by the continuous addition of air into the biosolids in order to maintain aerobic conditions.

To achieve Class B biosolids quality, aerobic digestion must provide at least 40 days of solids retention time (SRT, the average period of time the sludge remains in the digester), at 20 degrees Centigrade (68 degrees Fahrenheit) or 60 days at 15 degrees Centigrade (59 degrees Fahrenheit). Given the water temperatures at the Prescott wastewater treatment facilities, an SRT of 60 days is required to achieve Class B biosolids quality with aerobic digestion.

3.1.1 Advantages of Conventional Aerobic Digestion

- Aerobic digestion can produce Class B biosolids, providing beneficial reuse opportunities.
- The process is relatively simple to operate.

3.1.2 Disadvantages of Conventional Aerobic Digestion

- Due to the aeration requirements for digestion this process is relatively energy intensive.
- The process had the potential to generate odors and foam.
- The process is relatively land intensive due to the long SRT required to achieve Class B biosolids quality.
- Aerobic digestion is generally coupled with a secondary treatment process without primary clarification, which increases the required aeration basin volume and the overall energy consumption in the secondary treatment process.

3.1.3 Process Summary of Conventional Aerobic Digestion

Aerobic digestion is eliminated as a viable sludge stabilization treatment alternative for the City of Prescott due to the additional aeration requirements and associated energy costs. Consequently, aerobic digestion is not recommended for detailed evaluation.

3.2 Conventional Anaerobic Digestion

Anaerobic digestion is a widely used sludge stabilization process. This process, currently used at the Sundog WWTP, is capable of meeting Class B biosolids criteria when operated in the mesophilic temperature range (~35 degrees Celsius) with a SRT of at least 15 days.

The anaerobic digestion process can be divided into three stages. During hydrolysis, the proteins, cellulose, lipids, and other complex organics are made soluble. During the acid phase, acetogens convert the biodegradable organics into low molecular weight volatile fatty acids (VFAs). In the final stage, methanogens convert the VFAs into methane and carbon dioxide. In conventional anaerobic digestion, all of these phases occur within a single reactor. This can lead to operational challenges as both groups of bacteria (the acetogens and methanogens) have considerably different optimal conditions for growth. However, conventional anaerobic digestion is a well-established process that can reliably produce Class B biosolids when properly operated.

3.2.1 Advantages of Conventional Anaerobic Digestion

- Increased volatile solids reduction when compared to conventional aerobic digestion.
- Familiarity with process due to existing digestion facilities at Sundog WWTP.
- Compatibility with cogeneration technologies.

3.2.2 Disadvantages of Conventional Anaerobic Digestion

- Potential for odor and foam formation.
- Requires skilled operators.
- Relatively high capital cost.
- Safety issues with flammable gases.

3.2.3 Process Summary of Conventional Anaerobic Digestion

Anaerobic digestion is a viable sludge stabilization treatment alternative for the City of Prescott due to its ability to produce Class B biosolids, the familiarity of operations staff with the process, and its compatibility with the liquids treatment process. Consequently, anaerobic digestion is recommended for detailed evaluation.

3.3 Multi-Phase Anaerobic Digestion

Originally developed in the 1970s, the multi-phase anaerobic digestion process separates the acid and methane phases of conventional anaerobic digestion into two different phases occurring in different reactors. This separation promotes optimal growth conditions for the acidogenic and methanogenic bacteria, while also optimizing the process through manipulation of the loading rates and hydraulic detention time by using separate digestion vessels. To accomplish the phase separation, all of the waste solids are fed into a single small reactor where the volatile suspended solids (VSS) are converted into VFAs. The solids are then directed into a second reactor where the methanogenic organisms convert the VFAs into methane and carbon dioxide. This second reactor is much larger than the acid-phase reactor to provide adequate detention time for the microbial reactions. This system is also very flexible, allowing the acid phase to be taken in and out of service as needed without disrupting the methane phase or sacrificing biosolids quality.

Overall, this technology can produce pathogen limits comparable to Class A criteria when operated under mesophilic (35 degrees Celsius) - thermophilic (52 degrees Celsius) conditions (also referred to as “meso-thermo”). To be considered a Class A technology, additional monitoring is required to confirm coliform reductions will meet the PFRP requirements per Alternatives 3 and 4 summarized previously in Table A.1 in Technical Memorandum No. 8. Note that a third mesophilic phase can also provide additional reduction of odors, if required.

Table 3.1 summarizes the typical design parameters for multi-phase versus conventional anaerobic digestion.

Table 3.1 Typical Design Parameters for Conventional and Multi-Phase Digestion
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Conventional Anaerobic Digestion	Multi-Phase Anaerobic Digestion (Meso-Thermo)	
Hydraulic Retention Time	15-22 days	1-3 days	10-19 days
Temperature	95°F (35°C)	95°F (35° C)	125°F (52° C)
pH	7.0 - 8.0	5.0 - 5.5	7.5 - 8.5
Volatile Solids Reduction	50%	65%	
Solids Loading	0.12-0.13 lb VSS/day/cf	3 lb VSS/day/cf	N.A.

3.3.1 Advantages of Multi-Phase Anaerobic Digestion

- Increased volatile solids reduction.
- Increased dewaterability.
- Increased, cleaner-burning gas production.
- Compatibility with existing digestion facilities at Sundog WWTP.
- Compatibility with cogeneration technologies.

3.3.2 Disadvantages of Multi-Phase Anaerobic Digestion

- Requires skilled operators.
- Strong sidestream (supernatant).
- Safety issues with flammable gases.
- Requires additional monitoring to confirm Class A.
- Additional heating requirements as compared to conventional anaerobic digestion.

3.3.3 Process Summary of Multi-Phase Anaerobic Digestion

Multi-phase anaerobic digestion could be a viable sludge stabilization treatment alternative for the City of Prescott due to its flexibility, compatibility with existing digestion facilities at the Sundog WWTP as well as cogeneration technology, and its ability to produce EQ or Class A biosolids. This process may be cost-effective for the centralized treatment alternative at the Airport WRF (buildout capacity of 15 mgd), but not likely for separate treatment at each plant. However, a detailed evaluation of multiphase anaerobic digestion is not recommended at this point since the recommended approach to produce Class B biosolids would not justify the additional capital cost of multiphase digestion. It is important to note that this process can be retrofitted to a conventional anaerobic digestion process, and the City may consider evaluating this process at a later time should the need for higher biosolids quality require a closer evaluation of technologies capable to achieve Class A biosolids quality.

3.4 Temperature-Phased Anaerobic Digestion

Another advanced digestion technology that may achieve Class A biosolids criteria is temperature-phased anaerobic digestion. This technology uses temperature to improve the disinfection potential and physical separation of the digestion phases. There are various configurations, including mesophilic-thermophilic, thermophilic-mesophilic, and three-phase systems. Various configurations of these processes are now being tested at large wastewater treatment plants.

The most promising configuration is a mesophilic-thermophilic-mesophilic three-phase system. One of the main advantages of this type of system is that the odorous sludge produced in a thermophilic stage can be mitigated through the use of a subsequent mesophilic stage. In effect, this type of process combines the best aspects of thermophilic digestion (disinfection) and Two-Phase mesophilic digestion (VSS reduction, dewaterability, gas production, and non-odorous sludge).

3.4.1 Advantages of Temperature-Phased Anaerobic Digestion

- Produces Class A biosolids (PFRP equivalent with 1 day batch tanks at ~68 degrees Celsius).
- Has the potential to reduce odors typically associated with anaerobic digestion.

3.4.2 Disadvantages of Temperature-Phased Anaerobic Digestion

- Lowering the temperature from thermophilic temperatures to mesophilic temperatures is difficult because microorganisms become acclimated to initial temperatures. This can make the process difficult to control and maintain desired sludge quality.

- Potential odor and foam issues in the themophilic stage.
- Requires skilled operators.

3.4.3 Process Summary of Temperature-Phased Anaerobic Digestion

Temperature-phased anaerobic digestion will not be considered as a potential alternative sludge stabilization process for the City of Prescott to due to the operational difficulties associated with lowering process temperatures from the thermophilic to mesophilic range, while maintaining an efficient microorganism population capable of achieving the desired sludge stabilization.

3.5 Autothermal Thermophilic Aerobic Digestion (ATAD)

Aerobic digestion is a proven stabilization technology that offers a stable and consistent operation. Thermophilic aerobic digestion is a type of aerobic digestion capable of producing Class A biosolids. ATAD operates at a range of 50 degrees Celsius to 60 degrees Celsius (55 degrees Celsius optimally) and utilizes aerobic microorganisms. However, this technology rarely accomplishes destruction of the organic component beyond 40 percent of the feed. ATAD utilizes temperature to increase the biological activity, which reduces the detention time from 20-30 days to 8-12 days. The increase in temperature also reduces the number of pathogenic organisms to levels capable of meeting Class A requirements.

3.5.1 Advantages of ATAD

- Produces a Class A biosolids product.
- Short detention time requires smaller digester volumes.

3.5.2 Disadvantages of ATAD

- Although this technology was developed with the concept that the temperature would be self-regulating, the evaporation of water due to air saturation cools the digester, requiring supplemental heating.
- Significant foaming issues are typical due to the high oxygen demand associated with increased biological rates and high air rates for mixing.
- Aerobic digestion is very energy intensive.
- Requires skilled operators to monitor and control optimum temperature range.
- Odor potential due to degradation of the organic compounds at high temperatures.
- Air from the digesters typically requires scrubbing.
- Not compatible with cogeneration technologies.

3.5.3 Process Summary of ATAD

Due to the array of significant disadvantages outlined above, this technology is not considered to be a viable sludge stabilization process for the City of Prescott.

3.6 Thermal Treatment

Thermal (heat) treatment is the stabilization of raw sludge at elevated temperatures. The thermal treatment processes available in the U.S. include the Zimpro and the Ver-Tech systems. Both systems are wet-air oxidation processes, which use oxygen to convert biosolids to water, carbon dioxide, and an inert residual. The U.S. EPA identifies the Zimpro Process as a heat treatment process that could meet the PFRP or Class A requirements if operational parameters are met. Alternatively, the Ver-Tech process has not been approved by the EPA as a PFRP to date. However, both processes qualify as a PFRP if the raw sludge is heated to a temperature of 180 degrees Celsius or higher for 30 minutes.

3.6.1 Advantages of Thermal Treatment

- Zimpro process requires a shorter detention time than conventional digestion.
- Ver-Tech process can produce Class A biosolids as well as produce carbon dioxide, water, and a small amount of reusable sand-like residual that can be included in the admixture to make construction bricks.

3.6.2 Disadvantages of Thermal Treatment

- Zimpro process is very energy intensive and can also generate considerable odors.
- Zimpro requires additional dewatering and also produces a high color and organic sidestream, which is recycled to the headworks of the plant.
- Ver-Tech system requires 4,000-5,000 feet deep concentric tubes, and temperatures of 288 degrees Celsius and pressure of 1,500 psi to pressure oxidize organics.
- Neither of these processes are compatible with the existing digestion facilities at the Sundog WWTP and Airport WRF, requiring significant capital improvements to implement.

3.6.3 Process Summary of Thermal Treatment

Due to the energy requirements and other complications associated with thermal (heat) treatment processes, this technology is not considered to be a viable biosolids treatment alternative for the City of Prescott.

3.7 Thermal Drying

The thermal (heat) drying process must reduce the moisture content of the biosolids to 10 percent or lower in order to meet the Class A PFRP requirement. In addition, the temperature of the biosolids must be greater than 80 degrees Celsius or the wet bulb temperature of the gas in contact with the biosolids as it leaves the dryer must exceed 80 degrees Celsius.

Heat drying involves reduction of the moisture content of biosolids by induced evaporation. The feed sludge to the heat dryer must be mechanically dewatered to optimize the efficiency of the drying step. Heat drying utilizes mechanical agitation and auxiliary heat to increase the evaporation rate and has the capability and flexibility to produce pathogen free biosolids with any desired percent solids (up to nearly 100 percent). Heat drying alternatives include flash drying, spray drying, and rotary heat drying. The US EPA reports that the most common type of dryer currently used in handling biosolids is the rotary dryer.

Heat drying can be achieved via direct or indirect methods. Direct heating exposes biosolids to full contact with hot gases. Indirect drying uses hot gas to heat up surface(s), which then come in contact with the sludge to evaporate moisture from the biosolids. The disadvantage to direct dryers is that new hot gas needs to be generated to evaporate moisture from the biosolids. Furthermore, the gas must be treated prior to release into the atmosphere. Alternatively, indirect dryers can recycle the gas used to heat the surfaces, which saves on power costs. In the past, heat drying alternatives tended to have high energy costs and were not widely used. Newer technology has made heat drying less energy intensive and more feasible.

Thermal drying technologies are also affected by air emissions permitting requirements, including 40 CFR, Part 60 - *New Source Performance Standards* and 40 CFR, Part 61 - *National Emission Standards for Hazardous Air Pollutants*. The air pollutants of concern from a typical rotary drum-type thermal drying system are basically the byproducts of natural gas and/or digester gas combustion along with off-gases from the drying process. The main pollutants of concern are particulate matter less than 10 microns in diameter (PM10), volatile organic compounds (VOCs), sulfur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), hazardous air pollutants (HAPs), and trace amounts of metals. A natural gas or digester gas-fired regenerative thermal oxidizer (RTO) is typically used to control emissions of VOCs and CO. Up to 99 percent of VOCs and up to 85 percent of CO emissions can be controlled by the RTO. Any ammonia released from the sludge will also get oxidized to nitrogen dioxide (NO2) in the RTO. Additionally, particulate control devices, such as Venturi scrubbers, are also typically employed to reduce particulate emissions.

In addition to the dryer itself, a rotary drum-type dryer system will also be comprised of product-handling equipment, including conveyors, bucket elevators, screens, grinders, product-cooling equipment, and product storage bins or silos. These units are typically completely enclosed and ventilated to scrubbers or fabric filters to control particulate emissions.

3.7.1 Advantages of Thermal Drying

- Produces a Class A biosolids product.
- Compatibility with existing digestion facilities at Sundog WWTP.

3.7.2 Disadvantages of Thermal Drying

- Energy intensive.
- Air permitting requirements.

3.7.3 Process Summary of Thermal Drying

Thermal (heat) drying is a viable sludge stabilization technology for the City of Prescott, and is recommended for further evaluation. This alternative is best fitted for medium to large systems, and therefore it would be particularly well fitted for a regional facility approach to biosolids management.

3.8 Pasteurization

Pasteurization is intended to kill pathogens in raw sludge by elevating the temperature to 70 degrees Celsius or higher for 30 minutes or longer. Pasteurization must be performed in a batch process to prevent recontamination that might occur in a continuous feed process.

3.8.1 Advantages of Pasteurization

- Produces Class A biosolids.
- Increased pathogen destruction.

3.8.2 Disadvantages of Pasteurization

- Re-growth of pathogens and odors are potential concerns.
- Post-treatment with digestion or chemicals is required to eliminate pathogen re-growth.

3.8.3 Process Summary of Pasteurization

Pasteurization is not considered to be a viable sludge stabilization option for the City of Prescott due to the required post-treatment with digestion or chemicals.

3.9 Chemical Addition

Chemical addition processes are utilized to not only dewater and stabilize biosolids, but in some cases, to immobilize toxic compounds or heavy metals in a bonding matrix, thereby rendering the final product inert. Lime is often used to raise the pH to levels needed to reduce pathogens. The final product is suitable for amending acidic soils. Several chemical stabilization processes exist including alkaline stabilization and the commercial process

En-Vessel Pasteurization and N-Viro Corp., which are discussed further in subsequent sections.

3.9.1 Post-Dewatering Lime Stabilization

Post-dewatering lime stabilization involves adding dry lime to the biosolids cake and mixing it in a pug mill. Sufficient lime must be added to raise the pH to 12 for two hours of contact time. Following treatment, the final product must be mixed with a bulking agent and windrowed before it can be distributed or marketed.

3.9.1.1 Advantages of Lime Stabilization

- Potentially an EQ or Class A biosolids product when coupled with other stabilization processes.

3.9.1.2 Disadvantages of Lime Stabilization

- Requires combination with several other processes to produce Class A biosolids.
- Additional annual operational costs for chemicals and operations.
- Final alkaline material may not be suitable for all land types.
- Lime and bulking agents create a larger volume of ultimate biosolids requiring disposal.

3.9.1.3 Process Summary of Lime Stabilization

Due to the various disadvantages outlined above, post-dewatering lime stabilization is not considered to be a viable sludge stabilization option for the City of Prescott.

3.9.2 En-Vessel Pasteurization

En-Vessel Pasteurization uses chemical addition in combination with heat treatment. This commercial pasteurization method is available through RDP Technologies. RDP utilizes a patented process to reduce biological, municipal wastewater sludge pathogens and vector attraction properties by simultaneously mixing and heating lime and sludge. The technology uses electrical power to heat the sludge up to 70 degrees Celsius, while simultaneously adding lime to increase the pH to 12. The sludge is fed through a heated screw conveyor in which the material is heated and the chemicals are uniformly spread. The resulting product is a stabilized material that complies with Class A biosolids criteria.

3.9.2.1 Advantages of En-Vessel Pasteurization

- Produces Class A biosolids.
- Retention time is 30 minutes.

3.9.2.2 Disadvantages of En-Vessel Pasteurization

- Addition of chemical increases the overall volume of biosolids for disposal.
- Process is patented and therefore, potentially costly.
- Additional annual operational costs for chemicals and operations.

3.9.2.3 Process Summary of En-Vessel Pasteurization

Due to the various disadvantages outlined above, En-Vessel Pasteurization is not considered to be a viable sludge stabilization option for the City of Prescott.

3.9.3 N-Viro Chemical Stabilization

N-Viro Chemical Stabilization is a patented PFRP process (EPA approval in January 1988) in which cement kiln dust, lime kiln dust, lime, fly ash, or other alkaline material is added to dewatered biosolids. The mixture produces an exothermic reaction in which a minimum temperature of 52 degrees Celsius and a pH greater than 12 are achieved. The mixture is then stored at this condition for 12 hours. The material is then dried by thermal drying. The material must remain above a pH level of 12 for at least three days and be dried to at least 50 percent solids content at the completion of the process. A typical mixture is 1.25 parts alkaline material to 1.0 part biosolids. The final product can be used as a soil amendment or landfill alternative daily cover (ADC) material.

3.9.3.1 Advantages of N-Viro Chemical Stabilization

- Acceptable PFRP process capable of producing a Class A biosolids.

3.9.3.2 Disadvantages of N-Viro Chemical Stabilization

- Addition of chemical increases the overall volume of biosolids for disposal
- Potential high ammonia odors.
- Additional annual operational costs for chemicals and operations.
- Process is patented and therefore, potentially costly.
- Final alkaline product may not be suitable for all land types

3.9.3.3 Process Summary of N-Viro Chemical Stabilization

N-Viro Chemical Stabilization is not considered to be a viable treatment alternative for the City of Prescott for various reasons. Alkaline biosolids produced during alkaline stabilization are not always appropriate for land application. This process is also chemically intensive, and results in an increase in the volume of biosolids, odor, and biological growth. In addition, the N-Viro process is not an attractive option due to the high ammonia odor produced and the proprietary nature of the process.

3.10 Composting

Biosolids composting is a stabilization process whereby the organic constituents of the biosolids are aerobically decomposed. High temperatures achieved during the microbial decomposition reduce pathogenic organisms in the biosolids. The resultant humus-like material can be used as a soil amendment. The biosolids are typically dewatered prior to the composting process.

A bulking agent such as wood or paper waste is usually added to increase the carbon-to-nitrogen ratio. The bulking agent succeeds in producing higher quality biosolids as a soil amendment, raising the initial solids content of the mixture, and providing bulk porosity which is important for efficient aeration.

During the composting process, the volatile solids content of the digested biosolids is reduced. The bulking agent can become partially decomposed and the solids content of the mixture can increase. When composting is complete, the compost material is typically screened to retrieve a portion of the bulking agent. The product is typically cured for several days before it is bagged and labeled or distributed in bulk form. Composting operations can meet both Class A and Class B pathogen reduction requirements depending on time and temperatures met during the process.

Because compost products have generally been associated with food and yard waste or agricultural waste, the public is more familiar with compost products and is more likely to accept biosolids compost. In addition, because the composting process requires carbon sources, these nutrients could be supplied through the use of municipal organic waste. Composting can also incorporate water treatment residuals, which would serve as a bulking agent.

There are three basic types of composting processes discussed in the following sections: windrow composting, aerated static piles, and in-vessel composting.

3.10.1 Windrow Composting

In windrow composting, the biosolids and bulking agent mixture is formed into long, open-air piles. The biosolids are turned frequently to ensure an adequate supply of oxygen throughout the compost pile and to guarantee high, uniform temperatures throughout the pile for optimal pathogen reduction. Windrow composting requires a significant amount of land and, due to the odor potential, is generally limited to rural areas with low population densities.

3.10.2 Aerated Piles Composting

Aerated static piles rely on forced air to supply air for both decomposition and moisture removal. Air is supplied by blowers connected to perforated pipes running under the piles. The blowers draw or blow air into the piles, assuring even distribution of air throughout the composting biosolids mixture. A layer of previously composted biosolids placed over the surface of the pile helps to insulate the pile and assure that sufficient temperatures are achieved throughout the pile.

Aerated static pile composting is usually conducted within an enclosed building in order to collect and scrub the gases emitted from the process. A static pile composting facility would require a large parcel of land.

3.10.3 In-Vessel Composting

In this process, the feed biosolids, bulking agent, and recycled biosolids are fed into an enclosed vessel or reactor. Environmental conditions such as temperature and oxygen supply can be monitored and controlled inside the reactor. The biosolids mixture is maintained in an aerobic condition by forced air or continuous mixing. The air provides oxygen to the microorganisms and maintains decomposition rates of compost. The stabilization period in the system is approximately 14 to 21 days followed by an additional curing period of approximately 30 days. Curing is induced by stockpiling the composted material in a warehouse type building. Both the composting and curing locations would be fully enclosed, and air and odor emissions would be treated prior to releasing to the atmosphere. In-vessel systems are becoming more popular due to easier odor and gas emission collection and treatment, process control, and better public acceptance.

Currently, there are two basic types of in-vessel reactors, including a tunnel reactor and a plug-flow, agitated bay system. Tunnel reactors may be constructed either vertically or horizontally. The plug-flow agitated bay system is offered by several manufacturers. The agitated bay system consists of modular units of parallel walls (or bays). For both systems, biosolids and bulking agents are initially mixed before entering the systems.

3.10.3.1 Advantages (In-Vessel Composting only)

- General public acceptance.
- Requires a smaller footprint than other composting technologies.
- Allows for simple gas collection and scrubbing.
- Produces a Class A biosolids that may be sold to public.

3.10.3.2 Disadvantages (In-Vessel Composting only)

- Fire potential is high.
- Requires additional odor control equipment, a bulking agent, and a curing step, which requires additional process time and space.
- Requires 30 days of composted material storage (i.e. warehouse).

3.10.3.3 Process Summary of Composting

Due to the disadvantages outlined above, composting is not considered to be a viable sludge stabilization option for the City of Prescott. However, the technology is considered a potential option should a regional biosolids handling facility become a reality at any point in the future.

3.11 Biosolids to Energy (Incineration)

Incineration is the complete combustion or rapid exothermic oxidation of combustible materials such as fixed carbon, hydrogen, and sulfur in biosolids. Other combustible materials include grease and scum, which have very high fuel value. Incineration can produce a Class A material. Ash produced from the furnaces can be beneficially used and/or disposed in the same way as biosolids. Pyrolysis is an incineration process where the combustion process is starved for oxygen by supplying less air than is required for combustion. An afterburner is required to destroy particulate carry-over and odors.

3.11.1 Advantages of Biosolids to Energy

- Prior stabilization is not required, reducing the required digestion facilities.
- Reduces solids by up to 95 percent.
- Potential for energy (heat) recovery.
- Inert ash is non-hazardous and can be disposed in municipal landfills.

3.11.2 Disadvantages of Biosolids to Energy

- Incineration of biosolids is currently prohibited in Arizona.
- Requires specialized operations staff and significant safety measures.
- Potentially negative public perception due to older systems with poor air emissions.
- Air emissions must be carefully handled.

3.11.3 Process Summary of Biosolids to Energy

Because of the current prohibition of biosolids incineration in Arizona's present regulations, incineration is not a viable planning alternative for the City of Prescott. However, the technology could be considered a potential option should a regional biosolids handling facility become a reality at any point in the future, and should the current regulations change to allow biosolids incineration in the State of Arizona.

3.12 Biosolids Stabilization Alternatives Screening Summary

Based on the information presented in this Section 1.0, the following processes are recommended for in the biosolids alternatives evaluation for either separate treatment facilities or a centralized treatment plant at the Airport WRF:

- Conventional Anaerobic Digestion
- Thermal Drying

Processes that may be viable should a regional biosolids management facility become a long-term consideration include:

- Composting
- Thermal Drying
- Biosolids to Energy (Incineration)

4.0 BIOSOLIDS TREATMENT ALTERNATIVES EVALUATION

4.1 Sundog WWTP

Two alternatives for biosolids treatment were short-listed in Section 3 for near-term consideration, including conventional anaerobic digestion and thermal drying.

4.1.1 Anaerobic Digestion

Anaerobic digestion has been determined by the US EPA under 40 CFR Part 503 to be a Process that will Significantly Reduce Pathogens (PSRPs). In this process biosolids are treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature must be between 15 days at 35°C to 55°C and 60 days at 20°C. The City is currently operating below 15 day SRT and therefore must test for fecal coliforms in their biosolids to insure compliance. All alternatives for this analysis assume a minimum 15 day SRT for anaerobic digestion. In addition, the Part 503 rule requires that sludge stabilization processes must reduce the attractiveness of biosolids to vectors, thereby reducing the potential for transmitting diseases from pathogens in biosolids.

Average and maximum month sludge production values and corresponding sludge flows to the anaerobic digesters were calculated for Phase 1 and the ultimate flow capacity for Sundog WWTP in TM No. 5S and are summarized in Table 4.1.

Table 4.1 Sundog WWTP Sludge Production and Flow to Digesters Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
Parameter	**Unit**	**Volatile Solids**	**Total Solids**
Phase 1 (3.6 mgd): Solids Production Rate			
Average Month		10,082	11,783
Maximum Month	LBS/D	21,201	24,797
Ultimate (5.4 mgd): Solids Production Rate			
Average Month	LBS/D	15,122	17,718
Maximum Month		31,925	37,289
Thickened WAS & PS Solids Concentration	%TS		5%
Phase 1 (3.6 mgd): Total Flow to Digesters - Continuous			
Average Month	MGD		0.028
Maximum Month			0.060
Ultimate (5.4 mgd): Total Flow to Digesters - Continuous			
Average Month	MGD		0.043
Maximum Month			0.090

In order to ensure compliance with conventional design guidelines for volatile solids loading and EPA 503B requirements for Class B sludge, digestion capacity must be increased. The design criteria from TM No. 5S is summarized in Table 4.2.

Table 4.2 Sundog WWTP Anaerobic Digester Criteria Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
Parameter	**Unit**	**Phase 1 (3.6 mgd)**	**Ultimate (5.4 mgd)**
Number of Digesters	#	3	4
Diameter	ft	50	50
Depth	ft	25	25
Volume per Digester	ft^3	49,000	49,000
Hydraulic Retention Time (all in operation)	Days		
Average Month		39.0	34.6
Maximum Month		18.5	16.4
Hydraulic Retention Time (one OOS)	Days		
Average Month		26.0	25.9

The existing sludge dewatering belt filter press is at the end of its useful life and is undersized for future requirements. For the purposes of master planning, centrifuge technology is assumed for new dewatering facilities since it is a conservative cost assumption and is consistent with the recent centrifuge equipment installed at the Airport WRF. Alternative technologies will be considered during preliminary design. The centrifuge dewatering design criteria from TM No. 5S is summarized in Table 4.3.

Table 4.3 Sundog WWTP Digested Sludge Dewatering Criteria Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
Parameter	**Unit**	**Phase 1**	**Ultimate**
Number of Centrifuges	#	2	2
Centrifuge Hydraulic Capacity	gpm	150	150
Digested Solids Production (38% VS destruction)	Lbs/d (assuming 7 days of production is dewatered in 5 days)		
Average week		11,133	16,760
Maximum week		23,437	35,221
Digested Solids Flow (5 days/week)	mgd		
Average Day		0.04	0.06
Maximum Month		0.08	0.13
Digested Sludge Storage for Max Month	Million gallons	0.12	0.18
Centrifuge Operation (5 days/week)	Hrs/day		
Average week		4.4	6.7
Maximum week		8.9	14.4

4.1.2 Thermal Drying

Thermal Drying has been determined by the US EPA under 40 CFR Part 503 to be a Process that will Further Reduce Pathogens (PFRPs). In this process biosolids are dried by direct or indirect contact with hot gases to reduce the moisture content of the biosolids to 10 percent or lower. Either the temperature of the biosolids particles exceeds 80°C or the wet bulb temperature of the gas in contact with the biosolids as the biosolids leave the dryer must exceed 80^{O}C. The Part 503 rule also requires that sludge stabilization processes reduce the attractiveness of biosolids to vectors, thereby reducing the potential for transmitting diseases from pathogens in biosolids. Part 503 contains 12 options for demonstrating reduced vector attraction for biosolids. Thermal drying is expected to meet Option 8: Drying biosolids with unstabilized solids to at least 90 percent solids concentration.

Dryers reduce the moisture content of sludge and therefore are sized by the evaporative capacity of the equipment. For Sundog, dryer technology could be installed post anaerobic digestion, but for the purposes of this evaluation, the dryer will be sized for drying dewatered primary and waste activated sludge. Therefore the dryer must process dewatered cake with solids concentrations ranging from 20% to 25% depending on the dewaterability of the primary and waste activated sludge, and produce a dried, pelletized product with a solids concentration of at least 90% but more typically 93% or higher. In addition for marketing and reuse purposes, the pellets should be durable, with low dust content and a relatively uniform diameter for distribution by fertilizer spreaders.

Drying is mechanically intensive with solids conveyors and elevators and operations are potentially hazardous. Therefore for a reliable dryer system, the process must be sized to operate 4 to 5 days per week. This allows two days for routine maintenance and calibration of safety equipment and will not result in excessive storage facilities.

Average and maximum month sludge production values, and feed sludge flows to thermal drying were calculated for Phase 1 and the ultimate flows for Sundog WWTP in Table 4.4.

Table 4.4 Sundog WWTP Sludge Production and Flow to Thermal Drying
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Volatile Solids	Total Solids
Phase 1 (3.6 mgd): Solids Production Rate			
Average Month	LBS/D	10,082	11,783
Maximum Month		21,201	24,747
Ultimate (5.4 mgd): Solids Production Rate			
Average Month		15,122	17,718
Maximum Month	LBS/D	31,925	37,289
Thickened WAS & PS Solids Concentration	%TS		5%
Phase 1 (3.6 mgd): Total Flow to Thermal Drying			
Average Month	MGD		0.028
Maximum Month			0.060
Ultimate (5.4 mgd): Total Flow to Thermal Drying			
Average Month	MGD		0.043
Maximum Month			0.090

Table 4.5 Sundog WWTP Undigested Sludge Dewatering Criteria
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Phase 1	Ultimate
Number of Centrifuges	#	2	2
Centrifuge Hydraulic Capacity	gpm	150	150
WAS and Primary Solids Production	Lbs/d (7 days of production is dewatered in 5 days)		
Average Day		16,496	24,805
Maximum Month		34,716	52,205
WAS and Primary Solids Flow (5 days/week)	mgd		
Average Day		0.04	0.06
Maximum Month		0.08	0.13
WAS and Primary Sludge Storage for Max Month	Million gallons	0.12	0.18
Centrifuge Operation (5 days/week)	hrs/day		
Average Week		4.4	6.7
Maximum Week		8.9	14.4

Table 4.6 shows the evaporation requirements for Sundog assuming two conditions of sludge dryness; 20% TS and 25% TS.

Table 4.6 Sundog WWTP Thermal Drying Evaporative Capacity
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Phase 1 (3.6 mgd)	Ultimate (5.4 mgd)
Solids Production Rate (5 days per week)			
Average Month	LBS/D	16,496	24,805
Maximum Month	LBS/D	34,716	52,205
Undigested Sludge Dewatered Cake Solids Concentration	%TS	20 – 25%	20 – 25%
Required Evaporative Capacity			
Average Month	KG H20 /HR	940 – 1,250	1,410 – 1,880
Maximum Month	KG H20 /HR	1,970 – 2,630	2,960 – 3,950

There are a variety of alternative drying technologies available for the thermal drying of biosolids. One of the major suppliers to the North American Market is Andritz. Andritz provide three types of dryers depending on specific requirements.

Table 4.7 Biosolids Dryers Technology Key Features
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Dryer Technology	Key Features
Belt Drying Systems	• economic drying for smaller capacities • low temperatures by drying with waste heat • processing of fibrous materials • easy service and maintenance for intermittent operation
Fluidized Bed Drying Systems	• medium to large capacities • continuous operation • usage of secondary energy • lowest emissions
Drum Drying Systems	• medium to large capacities • intermittent and continuous operations • usage of primary energy • best pellet quality for agricultural use

For the Sundog WWTP the evaporative capacities are too low for fluidized bed or drum dryers, therefore the most appropriate dryer technology will be the belt drying system. A single dryer of capacity 4,000 kg/hr (8,800 lb/hr) will process maximum month sludge production from 7 days of production in 5 days. During current and Phase 1 flows, the dryer will have spare capacity that could be used for processing Airport WRF sludge.

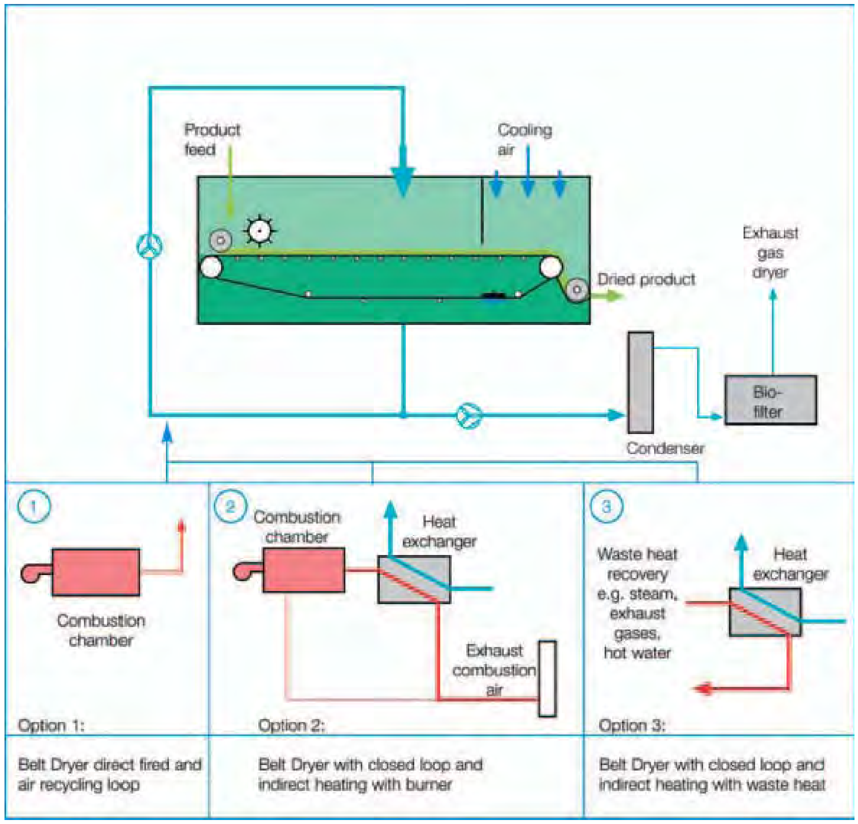

Figure 4.1 Belt Dryer Process Schematic (Courtesy of Andritz)[1]

4.1.3 Economic Analysis of Anaerobic Digestion and Thermal Drying

The capital costs and operating costs for anaerobic digestion and thermal drying are provided in Table 4.8 below. For the Sundog WWTP at the Phase 1 and ultimate flows, anaerobic digestion is the preferred economic alternative.

Table 4.8 Sundog WWTP Biosolids Alternatives Costs
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Criteria	Anaerobic Digestion	Thermal Drying
Probable Construction Cost	$5,426,000	$14,000,000
Annual O&M Costs	$340,100	$1,220,100
Total Life-Cycle Cost	$10,099,000	$27,990,000

Note:
(1) Present value costs assume a life-cycle period of 20 years, an interest rate of 6%, and an escalation rate of 2%.

1 http:// www.andritz.com

However the thermal dryer will produce a fertilizer product that has agricultural and recycling value, whereas dewatered anaerobic sludge has little value and in many jurisdictions has become a liability for municipal agencies. Given a long term view of biosolids disposal, the City of Prescott should consider planning for thermal drying of biosolids in a combined facility as flows increase and new residential construction re-starts.

4.2 Airport WRF

Two alternatives for biosolids treatment were short-listed in Section 3, including conventional anaerobic digestion and thermal drying. The Airport WRF currently has no solids stabilization process, and anaerobic digestion and thermal drying are generally not cost effective at plants rated less than 5 mgd. Therefore, this analysis will be conducted only for ultimate conditions (9.6 mgd).

4.2.1 Anaerobic Digestion

Average and maximum month sludge production values were calculated for ultimate flows for Airport WRF. Primary and waste activated sludge solids were taken or pro-rated from Table 8.9, of TM No. 8. The volatile solids concentration of the WAS is estimated to be 80% and the volatile solids concentration of the primary sludge is estimated to be 70%. The combination of thickened WAS and primary sludge is assumed at 5% prior to anaerobic digestion or thermal drying.

Table 4.9 Airport WRF Sludge Production and Flows to Digesters
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Volatile Solids	Total Solids
Ultimate (9.6 mgd): Total Solids	LBS/D		
Production Rate		27,360	33,243
Average Month		47,950	58,612
Maximum Month			
Thickened WAS & PS Solids Concentration	%TS		5%
Total Flow to Digesters – Continuous			
Average Month			0.08
Maximum Month			0.14

In order to ensure compliance with conventional design guidelines for volatile solids loading and EPA 503B requirements for Class B sludge, digestion capacity must be provided as indicated in Table 4.10. The limiting design condition for the ultimate capacity is the provision for removing one digester from service under annual average conditions.

Table 4.10 Airport WRF Anaerobic Digester Criteria
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Ultimate (9.6 mgd)
Number of Digesters	#	6
Diameter	ft	55
Depth	ft	25
Volume per Digester	ft^3	59,396
Hydraulic Retention Time (all in operation)	Days	
Average Month		33.4
Maximum Month		19.0
Hydraulic Retention Time (one OOS)	Days	
Average Month		27.9

For the purposes of master planning, centrifuge technology is assumed for new dewatering facilities since it is a conservative cost assumption and is consistent with the centrifuge equipment recently installed at the Airport WRF. Therefore two duty and one standby centrifuge will be installed. Digested sludge storage will also be required to facilitate dewatering for only 5 days in a week as shown in Table 4.11.

**Table 4.11 Airport WRF Digested Sludge Dewatering Criteria
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona**

Parameter	Unit	Ultimate (9.6 mgd)
Number of Centrifuges	#	3
Centrifuge Capacity (Maximum)	gpm	150
Digested Solids Production (5 days/ week and 38% VS destruction)	Lbs/d (assuming 7 days of production is dewatered in 5 days)	
Average week		31,985
Maximum week		56,547
Digested Solids Flow (5 days/week)	mgd	
Average Day		0.11
Maximum Month		0.20
Digested Sludge Storage for Max Month	Million gallons	0.28
Centrifuge Operation (5 days/week)	Hrs/day	
Average week		6.1
Maximum week		11.1

4.2.2 Thermal Drying

Average and maximum month sludge production values, and sludge flows prior to drying were calculated for the ultimate flows for Airport WRF and are presented in Table 4.12. Undigested sludge dewatering criteria for the heat drying alternative are given in Table 4.13.

**Table 4.12 Airport WRF Sludge Production and Flows to Thermal Drying
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona**

Parameter	Unit	Volatile Solids	Total Solids
Ultimate (9.6 mgd): Total Solids Production Rate	LBS/D		
Average Month		27,360	33,243
Maximum Month		47,950	58,612
WAS & PS Solids Concentration (after thickening)	%TS		5%
Ultimate: Total Flow - Continuous	MGD		
Average Month			0.08
Maximum Month			0.14

Table 4.13 Airport WRF Undigested Sludge Dewatering Criteria Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Parameter	**Unit**	**Ultimate (9.6 mgd)**
Number of Centrifuges	# (N+1)	3
Centrifuge Capacity (Maximum)	gpm	150
WAS and Primary Solids Production (5 days/week)	Lbs/d	
Average Day		46,540
Maximum Month		82,060
WAS and Primary Solids Flow (5 days/week)	mgd	
Average Day		0.11
Maximum Month		0.20
WAS and Primary Sludge Storage for Max Month	Million gallons	0.28
Centrifuge Operation (5 days/week)	Hrs/day	
Average Day		6.1
Maximum Month		11.1

As mentioned previously for sizing dryers, the evaporation requirements for the dewatered sludge must be determined. Table 4.14 presents the evaporation requirements for Airport WRF for two conditions of cake solids concentration: 20% TS and 25% TS.

Table 4.14 Airport WRF Thermal Drying Evaporative Capacity Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Parameter	**Unit**	**Ultimate**
Solids Production Rate (5 days per week) Average Month Maximum Month	LBS/D	46,540 82,060
WAS & PS Solids Dewatered Concentration	%TS	20 – 25%
Evaporative Capacity Average Month Maximum Month	KG/HR	2,640 – 3,520 4,660 – 6,210

There are a variety of alternative drying technologies available for the thermal drying of biosolids as mentioned previously. Andritz provide three types of dryers depending on specific requirements.

For Airport WRF the evaporative capacities are too low for fluidized bed or belt dryers, except at maximum month conditions. Therefore the most appropriate dryer technology will be the rotary drum. One dryer of capacity 6,200 kg/hr (13,700 lb/hr) will process maximum month sludge production from 7 days of production in 5 days.

4.2.3 Economic Analysis of Anaerobic Digestion and Thermal Drying

The capital costs and operating costs for anaerobic digestion, and thermal drying are provided in the tables below. For Airport WRF at current and ultimate flows, anaerobic digestion is the preferred economic alternative, as shown in Table 4.15.

Table 4.15 Airport WRF Biosolids Alternatives Costs Comparison
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Criteria	Anaerobic Digestion	Thermal Drying
Probable Construction Cost	$22,680,000	$35,700,000
Annual O&M Costs	$544,600	$2,192,000
Total Life-Cycle Cost	$30,163,000	$46,840,000

Note:
(1) Present value costs assume a life-cycle period of 20 years, an interest rate of 6%, and an escalation rate of 2%.

The thermal dryer will produce a fertilizer product that has agricultural and recycling value, whereas dewatered anaerobic sludge has little value and in many jurisdictions has become a liability for municipal agencies. Given a long term view of biosolids disposal, the City of Prescott may want to consider planning for thermal drying of biosolids in a combined facility as flows increase and new residential construction re-starts.

4.3 Centralized Airport WRF Alternatives

Two alternatives for biosolids treatment were short-listed in Section 3, including conventional anaerobic digestion and thermal drying. The Airport WRF currently has no solids stabilization process, and anaerobic digestion and thermal drying are generally not cost effective at plants rated less than 5 mgd. Therefore, this analysis will be conducted only for ultimate conditions (15 mgd).

4.3.1 Anaerobic Digestion

Average and maximum month sludge production values were calculated for ultimate flows for the Regional WWTP. Ultimate solids load were calculated by summing sludge from Sundog WWTP and Airport WRF. The sludge will be 5% solids concentration prior to anaerobic digestion. Table 4.16 establishes the flow and load to the digesters.

Table 4.16 Centralized Airport WRF - Sludge Production and Flows to Digesters
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Volatile Solids	Total Solids
Ultimate (15 mgd): Total Solids Production Rate			
Average Month		42,482	50,961
Maximum Month	LBS/D	79,875	95,901
WAS & PS Solids Concentration	%TS		5%
Thickened Sludge Flow – Continuous			
Average Month	MGD		0.12
Maximum Month			0.23

In order to ensure compliance with conventional design guidelines for volatile solids loading and EPA 503B requirements for Class B sludge, digestion capacity must be provided as indicated in Table 4.17. The limiting design condition for ultimate capacity is the provision for removing one digester from service.

Table 4.17 Centralized Airport WRF Anaerobic Digester Criteria
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Ultimate (15 mgd)
Number of Digesters	#	5
Diameter	ft	75
Depth	ft	25
Volume per Digester	ft^3	110,447
Hydraulic Retention Time (all in operation)	Days	
Average Month		32.7
Maximum Month		17.4
Hydraulic Retention Time (one OOS)	Days	
Average Month		26.1

For the purposes of master planning, centrifuge technology is assumed for new dewatering facilities since it is a conservative cost assumption and is consistent with the centrifuge equipment recently installed at the Airport WRF. Digested Sludge storage will also be required to facilitate dewatering for only 5 days in a week. The dewatering design criteria is given in Table 4.18.

Table 4.18 Centralized Airport WRF Digested Sludge Dewatering Criteria Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona		
Parameter	**Unit**	**Ultimate (15 mgd)**
Number of Centrifuges (N+1)	#	3
Centrifuge Capacity (Maximum)	gpm	150
Digested Solids Production (5 days/week and 38% VS destruction)	Lbs/d	
Average week		48,745
Maximum week		91,768
Digested Solids Flow (5 days/week)	mgd	
Average Day		0.12
Maximum Month		0.23
Digested Sludge Storage for Max Month	Million gallons	0.46
Centrifuge Operation (5 days/week)	Hrs/day	
Average (Total/per unit)		6.8
Maximum Month (Total/per Unit)		12.8

4.3.2 Thermal Drying

Average and maximum month sludge production values, and sludge flows prior to drying were calculated for the ultimate flows for the Centralized Airport WRF in Table 4.19.

Table 4.19 Centralized Airport WRF Sludge Production and Flows to Thermal Drying Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
Parameter	**Unit**	**Volatile Solids**	**Total Solids**
Ultimate (15 mgd): Total Solids Production Rate	LBS/D		
Average Month		42,482	50,961
Maximum Month		79,875	95,901
WAS & PS Solids Concentration	%TS		5%
Thickened Sludge Flow – Continuous	MGD		
Average Month			0.12
Maximum Month			0.23

The thickened sludge at 5% would be further dewatered with dewatering centrifuges as shown in Table 4.20.

Table 4.20 Centralized Airport WRF Undigested Sludge Dewatering Design Criteria Drying
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Ultimate
Number of Centrifuges	#	3
Centrifuge Capacity (Maximum)	gpm	150
WAS and Primary Solids Production (5 days/week)	Lbs/d	
Average Day		71,345
Maximum Month		134,261
WAS and Primary Solids Flow (5 days/week)	mgd (7 days of production is dewatered in 5 days)	
Average Day		0.17
Maximum Month		0.32
WAS and Primary Sludge Storage for Max Month	Million gallons	0.64
Centrifuge Operation (5 days/week)		
Average Day per firm unit	Hrs/day	9.5
Maximum Month per firm unit		17.9

As mentioned previously for sizing dryers, the evaporation requirements for the dewatered sludge must be determined. Table 4.21 presents the evaporation requirements for the centralized Airport WRF assuming two conditions of dewatered cake solids concentration: 20% TS and 25% TS.

Table 4.21 Centralized Airport WRF Thermal Drying Evaporative Capacity
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Unit	Ultimate (15 mgd)
Solids Production Rate (5 days per week) Average Month Maximum Month	LBS/D	71,345 134,261
WAS & PS Solids Dewatered Concentration	%TS	20 – 25%
Evaporative Capacity Average Month Maximum Month	KG/HR	4,050 – 5,400 7,600 – 10,160

The evaporative demand for ultimate load is within the operating range of rotary drum dryers. One dryer of capacity 10,200 kg/hr (22,500 lb/hr) will process maximum month sludge production from 7 days of production in 5 days.

4.3.3 Economic Analysis of Anaerobic Digestion and Thermal Drying

The capital costs and operating costs for anaerobic digestion and thermal drying are provided in Table 4.22. For the Centralized Airport WRF at ultimate flows, anaerobic digestion is the preferred economic alternative.

The thermal dryer will produce a fertilizer product that has agricultural and recycling value, whereas dewatered anaerobic sludge has little value and in many jurisdictions has become a liability for municipal agencies. Given a long term view of biosolids disposal, the City of Prescott may want to consider planning for thermal drying of biosolids in a combined facility as flows increase and new residential construction re-starts. In addition, the City may wish to include biosolids-to-energy (incineration) as a viable alternative for consideration for a Regional WWTP. Detailed evaluation of biosolids-to-energy is beyond the scope of this study.

Table 4.22 Capital Costs and Operating Costs
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Criteria	Anaerobic Digestion	Thermal Drying
Probable Construction Cost	$25,760,000	$35,700,000
Annual O&M Costs	$732,000	$3,362,000
Total Life-Cycle Cost	$35,818,000	$75,250,000

Note:
(1) Present value costs assume a life-cycle period of 20 years, an interest rate of 6%, and an escalation rate of 2%.

5.0 SLUDGE GAS UTILIZATION ALTERNATIVES

5.1 Introduction

The purpose of this chapter is to review biogas utilization options for the Sundog WWTP and the centralized treatment facility alternative at Airport WRF. If separate treatment plants are maintained at both the Sundog WWTP and the Airport WRF there is no current recommendation for anaerobic digestion at the Airport WRF. The biogas utilization options considered in this evaluation include process heating and on-site power generation. Economic and non-economic considerations and life cycle costing were used to evaluate potential biogas utilization alternatives.

5.1.1 Background

Biogas produced through anaerobic digestion is a prime source of energy that is traditionally used for process heat (digestion and/or heat drying), building heat, or to generate power. Heat recovery from on-site power generation or drying can also be employed to heat digesters and buildings. The costs and benefits of biogas utilization vary depending on capacity requirements, purchased energy costs, biogas cleaning requirements, and process heat requirements.

5.2 Biogas Utilization Options

Biogas produced during anaerobic digestion can be used for many different purposes including fuel for boilers to produce steam or hot water, fuel for the dryer equipment to remove moisture from the solids (with heat recovery to heat digesters), or in combined heat and power (CHP) systems such as combustion turbine or engine generator to produce electric power and hot water from heat recovery for digester heating. In many locations, the biogas can also be cleaned to “near” natural gas quality and injected into natural gas transmissions pipelines. Biogas utilization options for process heat and on-site power generation were considered for this evaluation. Pipeline injection, which requires significant additional biogas cleaning equipment, is not expected to be cost effective for the Sundog or Centralized treatment facility capacities and was not given detailed consideration for this evaluation.

A schematic of the options considered for this evaluation is presented on Figure 5.1.

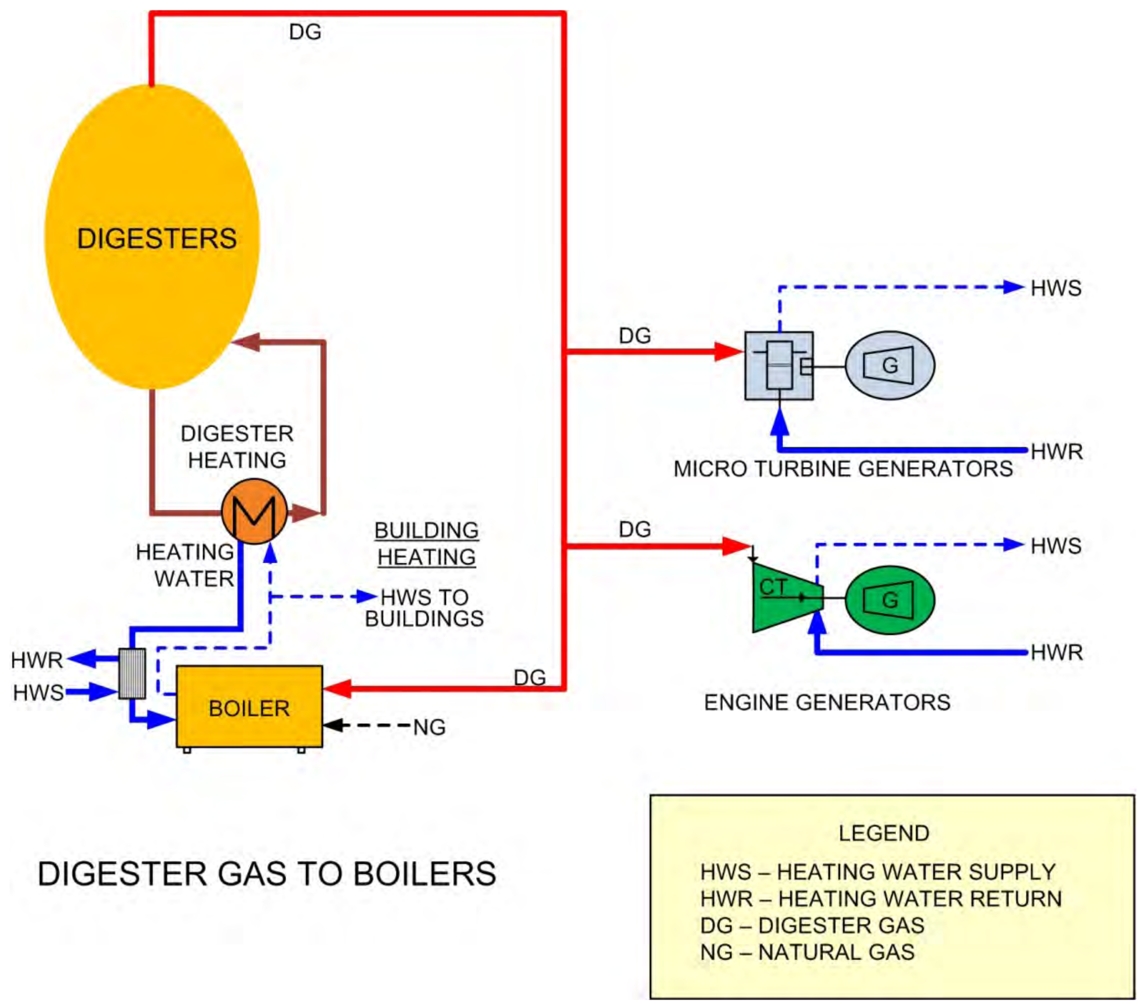

Figure 5.1 Biogas Utilization Options

5.2.1 Biogas to Boilers

Use of biogas to fire boilers is the most common biogas utilization option. Hot water from the boilers can be used for digester or building heat. The boilers are typically designed to fire on natural gas at digester start-up or when adequate quantities of biogas are not available. Boiler systems can burn biogas and natural gas simultaneously, with the lead boiler burning biogas and second boiler burning natural gas. Biogas production usually exceeds digester heating requirements, with surplus heat available seasonally, particularly in the warmer months. Boilers can also be used to produce steam for digester and building heating, and building cooling with the use of steam fired absorption chillers. If all the biogas is not used, the surplus is combusted using a flare. Figure 5.2 illustrates biogas use in boilers. A boiler efficiency of 80 percent conversion to useable heat is common and was used for this evaluation.

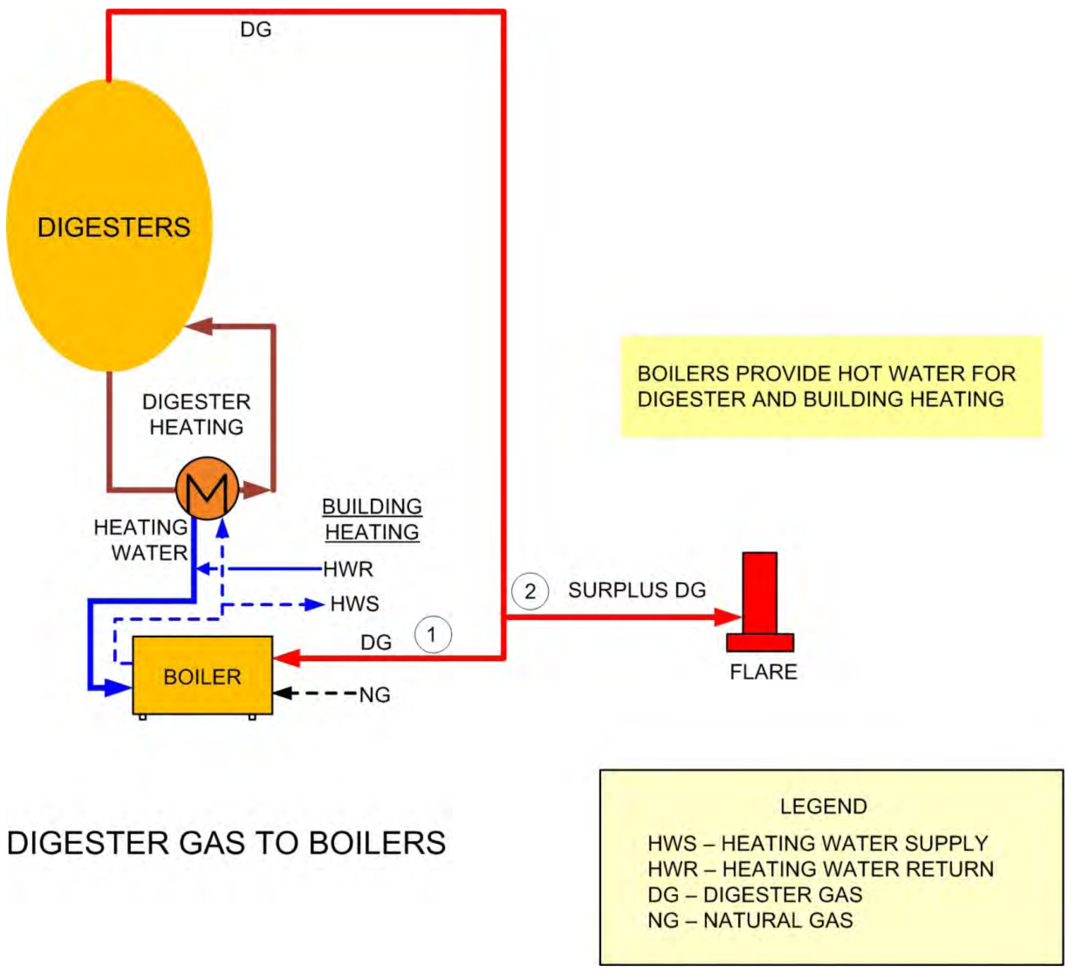

Figure 5.2 Biogas Use in Boilers

5.2.2 Biogas to Thermal Dryers

Plants that have thermal drying processes use available biogas for the dryer to reduce purchased energy requirements. Plants can typically reduce their natural gas costs by 50 to 80 percent, depending on the gas production and dewatered cake characteristics. Heat can be recovered from the dryer scrubber water or dryer condensate to heat digesters. However, since thermal drying was not recommended for the Sundog WWTP, Airport WRF, or Centralized WWTP, this utilization option was not considered in detail.

5.2.3 Biogas to Combined Heat and Power

Biogas can be fired in internal combustion engines, turbines, or fuel cells to generate power and mechanical energy. Heat, which can be recovered from the engine water jackets and exhaust in the form of hot water, can be used for process heating. These systems, known as Combined Heat and Power (CHP), are discussed in the following sections. A comparison of the CHP technologies is presented in Table 5.1. Costs have been adjusted from the original 2007 cost basis to 2010 values using ENR indices.

Table 5.1 Typical Performance Characteristics and Costs of CHP Technologies[1]
Technical Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Technology	Units	Gas Engine	Micro-Turbine	Fuel Cell
Power efficiency	%	22-40	18-27	30-63
Overall efficiency	%	70-80	65-75	55-80
Effective electrical efficiency	%	70-80	50-70	55-80
Typical capacity	kW_e	10-5,000	30-250	5-2,000
Availability	%	92-97	90-98	>95
Installed costs	$\$/kW_e$	1,200-2,400	3,600-3,200	5,400-6,400
O&M costs	$\$/kW_e$	0.010-0.024	0.013-0.027	0.034-0.041
Fuel pressure	Psi	1-45	50-80 (Compressor)	0.5-45

Note:
[1] From Catalog of CHP Technologies, U.S. EPA

Biogas to Engine Generators

Many plants produce power on-site using engine generators or combustion turbine generators. Biogas produced in the digestion process is used for power generation and the waste heat from the generators (in the form of hot water) is used to heat the digesters. Most plants generate enough electricity to provide about 30 percent of their plant power requirements. The hot water heat produced by the engine generators provides heating for digestion requirements. Depending on the climate and biogas production, the waste heat from the generators typically offsets digester heat requirements for 6 to 8 months per year and may have some additional heat available for building heating during all but the coldest months. As is the case with all biogas utilization options, boilers are provided to use biogas for digester heating in the event the engine generators are not operating. Spare engine generation capacity is not typically provided. Figure 5.3 illustrates an engine generation process.

A biogas-to-electricity conversion efficiency of 30-35 percent is typical with a heat recovery of 45 percent of input energy, for an overall system efficiency of 80 percent. The power efficiency is assumed 35 percent for this evaluation. This system efficiency is reduced due to maintenance downtime for the engine generators. Contaminants in the biogas will cause maintenance problems in the engine generators. Consequently, gas treatment is required for engine generators. A gas compressor is also required to boost gas pressure to compensate for pressure losses of the gas treatment and to provide sufficient gas pressure to the engines.

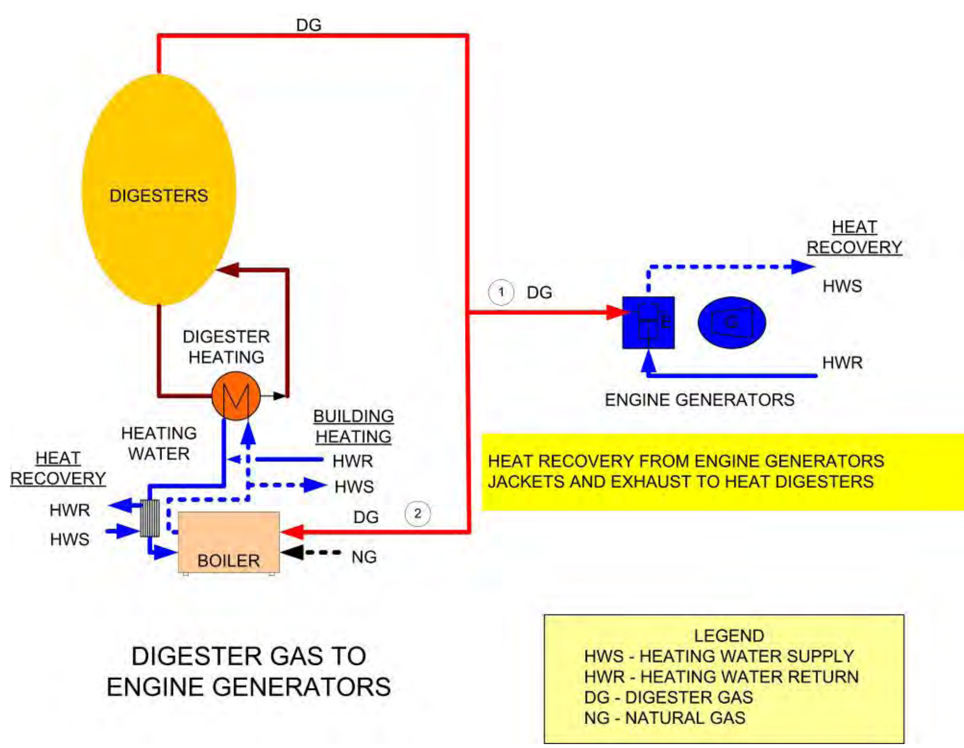

Figure 5.3 Biogas Use in Engine Generators

Biogas to Combustion Turbine (MicroTurbine®) Generators

Small modular combustion turbines (MicroTurbines) can be used in CHP systems to generate electricity. MicroTurbines are available at 30 kW, 60 kW and 200 kW capacities from Capstone Turbine Cooperation. Small combustion turbines are also available from other manufacturers; however, they do not have advantages similar to MicroTurbines and are not included in this discussion. MicroTurbines have the advantage of being able to operate as a single unit, allowing individual units to turn on and off to match gas production or loads. The MicroTurbines have heat recovery modules to produce hot water for digester or building heat from exhaust gases. MicroTurbine units are unique in that they operate at very high speeds but have few rotating parts. These systems typically have biogas-to-electricity conversion efficiencies of 26 percent (at 75 ^{o}F rating temperature), and heat recovery of 36 percent of input energy was used for an overall system efficiency of 62 percent. This overall efficiency is reduced due to maintenance downtime for the engine generators. Biogas treatment to remove contaminants is required for MicroTurbines. Figure 5.4 illustrates energy production using MicroTurbines.

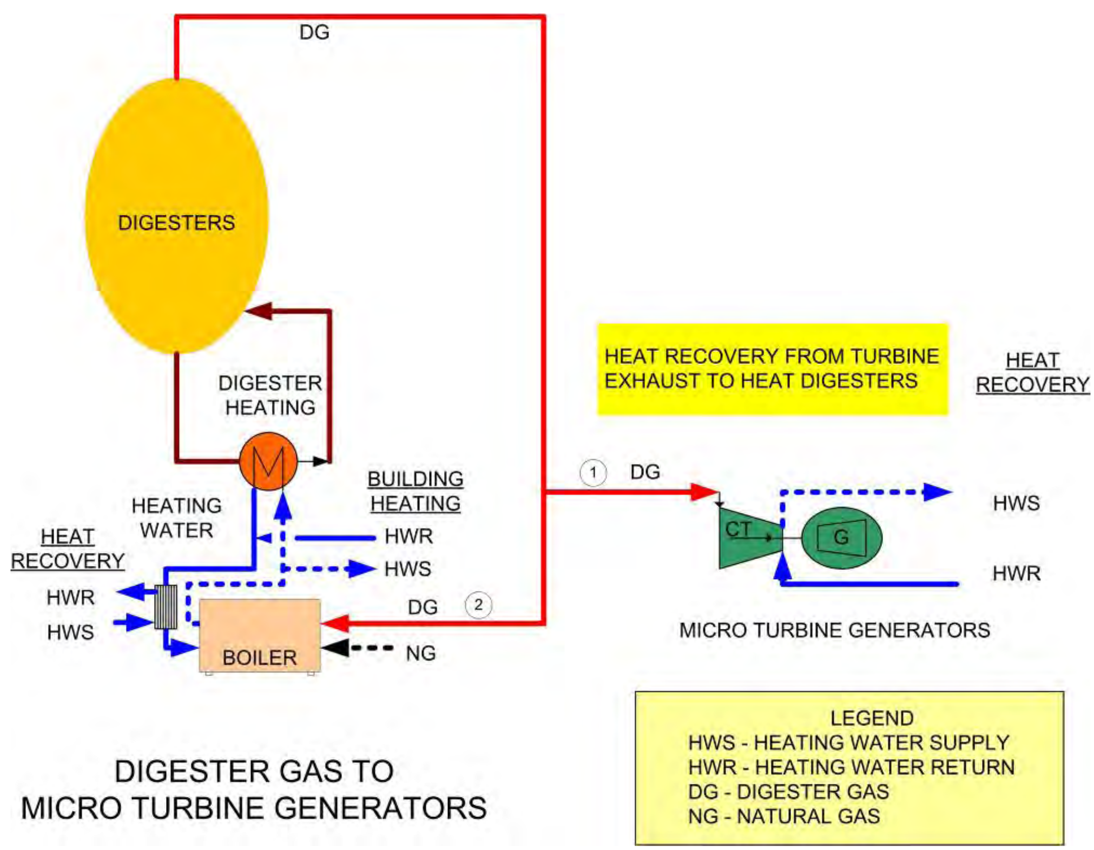

Figure 5.4 Biogas Use in MicroTurbines

Biogas to Fuel Cells

Fuel cells are electrochemical devices that generate electricity using hydrogen. The methane (CH_4) contained in biogas is the source of hydrogen for the fuel cells. Biogas based fuel cells is a relatively a new technology and is typically not cost effective unless grants or outside funding is available. Consequently, fuel cells were not given detailed consideration in this evaluation.

5.2.4 Biogas to Mechanical Energy

Biogas-fired internal combustion engines can be used to produce mechanical energy suitable to drive equipment, such as pumps or blowers. As with engine generators, waste heat from the engines can be used to for digester or building heat. Blowers must have specialized equipment to accommodate gas-fired engines. The engines are typically equipped to operate on both biogas and natural gas. If no gas is available, the blower motors operate on commercial power. This technology is not widely used in the wastewater treatment industry and was not given detailed consideration in this evaluation.

5.2.5 Evaluated Biogas Utilization Options

Three biogas utilization options were listed for detailed evaluation for each treatment facility. The options were as follows:

1. Biogas use for process (anaerobic digester) heat.
2. Biogas use in engine generators for on-site power generation and waste heat recovery.
3. Biogas use in MicroTurbines for on-site power generation and waste heat recovery.

Equipment requirements and costs were developed for each alternative at both the Sundog WWTP and the centralized treatment facility at the Airport WRF. In addition, costs were developed for a “base case” scenario. The “base case” scenario represents no energy recovery and flaring of all biogas. Natural gas must be purchased for digester heating in the “base case” scenario.

5.3 Projected Gas Production

Biogas productions were estimated for the Sundog WWTP and centralized treatment facility at Airport WRF. Solids quantities used for biogas production evaluation were calculated using the unit solids production rates presented in TM No. 8 – *Biosolids Planning Conditions* and the plant flow rate at the listed biogas utilization condition.

According to the USEPA, a minimum 15 days of solids retention time (SRT) is required for anaerobic mesophilic digesters to meet Class B pathogen criteria. Using the 15 day criterion, the existing digestion facility at the Sundog WWTP, with a primary digester volume of 0.37 MG, can support a digester feed flow of approximately 24,700 gpd, at 4 percent TS, or 8,220 pounds per day (ppd) solids. This digester feed corresponds to a plant influent flow of approximately 3 million gallons per day (mgd). The solids quantities used for biogas production calculation at the Sundog WWTP are presented in Table 5.2.

A 6 mgd flow to the centralized treatment facility at the Airport WRF was used for this evaluation with an assumption of equal contribution from the Sundog and Airport collection systems. Although the centralized plant is projected to have an ultimate capacity of 15 mgd, the expected plant flow for the next 5 to 10 years (near term) was used as the basis of this evaluation to prevent oversizing equipment and overestimating potential electricity production. If the centralized treatment facility grows at a more rapid rate, cost effective on-site power production may be achievable in a shorter time and/or larger capacity cleaning and generation equipment should be considered for the plant.

The solids quantities used for biogas production calculation at the Centralized Airport WRF are presented in Table 5.2.

Table 5.2 Solids Quantities at the Centralized Treatment Facility Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona

Parameter	Units	Individual Airport WRF 3 mgd Plant Flow AA Condition	Individual Sundog WWTP 3 mgd Plant Flow AA Condition[2]	Centralized Airport WRF 6 mgd Plant Flow AA Condition
Plant Flow	mgd	3.0	3.0	6.0
Primary Solids	ppd	8,500	4,500	13,000
	lb/MG	2,800	1,500	2,200
WAS	ppd	1,900	3,700	5,600
	lb/MG	640	1,200	940
Total Solids	ppd	10,300	8,200	18,600

Notes:
[1] From TM8 – Biosolids Planning Conditions.
[2] From Table 5.2.

The biogas production calculations were based on the solids quantities presented in Table 5.2. Digestion performance (and corresponding biogas production) was based on digester feed volatile solids of 75 percent for primary solids (PS) and 82 percent for waste activated sludge (WAS), using a gas production rate of 16 standard cubic feet per day (scf/lb) volatile solids destroyed (VSr). The calculated biogas production at the Sundog WWTP and the Centralized Treatment Facility are presented in Table 5.3 and Table 5.4.

Table 5.3 Digester Performance and Biogas Production at the Sundog WWTP
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Units	3 mgd Plant Flow AA Condition
Total solids	ppd	8,200
Volatile solids	ppd	6,400
Volatile solids reduction	%	45
Volatile solids reduction	ppd	2,900
Gas production[1]	cfd	46,200
Biogas energy[2]	mmBtu/day	28
Biogas energy[2]	mmBtu/hr	1.2

Notes:
[1]Based on gas production of 16 cf/lb VS destroyed
[2]Based on 600 Btu/cf

Table 5.4 Digester Performance and Biogas Production at the Centralized Airport WRF
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Units	6 mgd Plant Flow AA Condition
Total solids	ppd	18,600
Volatile solids	ppd	14,400
Volatile solids reduction	%	45
Volatile solids reduction	ppd	6,500
Gas production[1]	cfd	103,300
Biogas energy[2]	mmBtu/day	62
Biogas energy[2]	mmBtu/hr	2.6

Notes:
[1]Based on gas production of 16 cf/lb VS destroyed
[2]Based on 600 Btu/cf

Depending on its use, biogas must be cleaned to remove contaminants, including moisture sediment, hydrogen sulfide (H_2S) and siloxanes. Appropriate gas cleaning equipment has been assumed for each of the evaluated options.

5.4 Power Generation and Energy Recovery Estimates

Power generation and energy recovery estimates were calculated for the three evaluated alternatives, using the projected biogas productions presented in Section 5.3. Descriptions of each evaluated alternative and power generation and energy recovery are presented in the following section.

- Case 1 - All biogas to the boiler for digester heating. Excess biogas is flared. This configuration is widely used at WWTPs equipped with anaerobic digestion.
- Case 2 - All gas to engine generators. Heat recovered from the engine generator jackets and exhaust is used for digester heating.
- Case 3 - All gas to MicroTurbines. Heat recovered from the MicroTurbine exhaust is used for digester heating.

Energy recovery and electrical energy production from biogas for each of the evaluated alternatives has been estimated based on the gas production calculations listed in Table 5.3 and Table 5.4. Energy recovery and power estimates for design average annual conditions for the evaluated gas utilization alternatives are presented in Table 5.5 and Table 5.6 for Sundog WWTP and the Centralized Treatment Facility, respectively.

Table 5.5 Biogas Energy Recovery Estimates for Sundog WWTP
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Parameter	Units	Case 1 Process Heat	Case 2 Engine Generator	Case 3 MicroTurbine
Available biogas	mmBtu/hr	1.2	1.2	1.2
Power efficiency	%	NA[1]	35	26
Potential Electrical power	kWh/hr	NA	120	90
Potential Electrical power	MWh/yr	NA	1,040	770
Heat recovery efficiency	%	80	45	36
Potential Heat Recovery	mmBtu/hr	0.92	0.52	0.42

Note:
[1]Not applicable

Table 5.6 Biogas Energy Recovery Estimates for Centralized Treatment Facility Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona				
Parameter	**Units**	**Case 1 Process Heat**	**Case 2 Engine Generator**	**Case 3 MicroTurbine**
Available biogas	mmBtu/hr	2.6	2.6	2.6
Power efficiency	%	NA[1]	35	26
Potential Electrical power	kWh/hr	NA	270	200
Potential Electrical power	MWh/yr	NA	2,300	1,700
Heat recovery efficiency	%	80	45	36
Potential Heat Recovery	mmBtu/hr	2.07	1.16	0.93

Note:
[1]Not applicable

Digester heating requirements at each plant were calculated based on the number and type of digesters, local monthly average temperature profile, and digester feed quantities. Since performance data for digesters at the Centralized Airport WRF is not available, the evaluation was based on use of similar digesters to those at the Sundog WWTP, sized to provide a 15 day SRT for the combined solids production.

CHP systems typically do not have enough waste heat to provide adequate energy for digester heating during the coldest months of the year. In order to identify the months when the available waste heat available was not adequate for digester heating needs, calculated monthly digester heat requirements were compared to the estimated monthly heat recovery for each alternative. Supplemental natural gas must be purchased during months that the recovered heat from the CHP system did not meet digester heating requirements. The results of the CHP waste heat vs. digester heating requirements for engine generators and MicroTurbines at the Sundog plant are presented on Figure 5.5. As shown on the figure, the waste heat from the engine generators is expected to be adequate for digester heating under all monthly average conditions. However, waste heat from MicroTurbines is estimated to inadequate for digester heating during January, February, and December and will require purchase of supplemental natural gas.

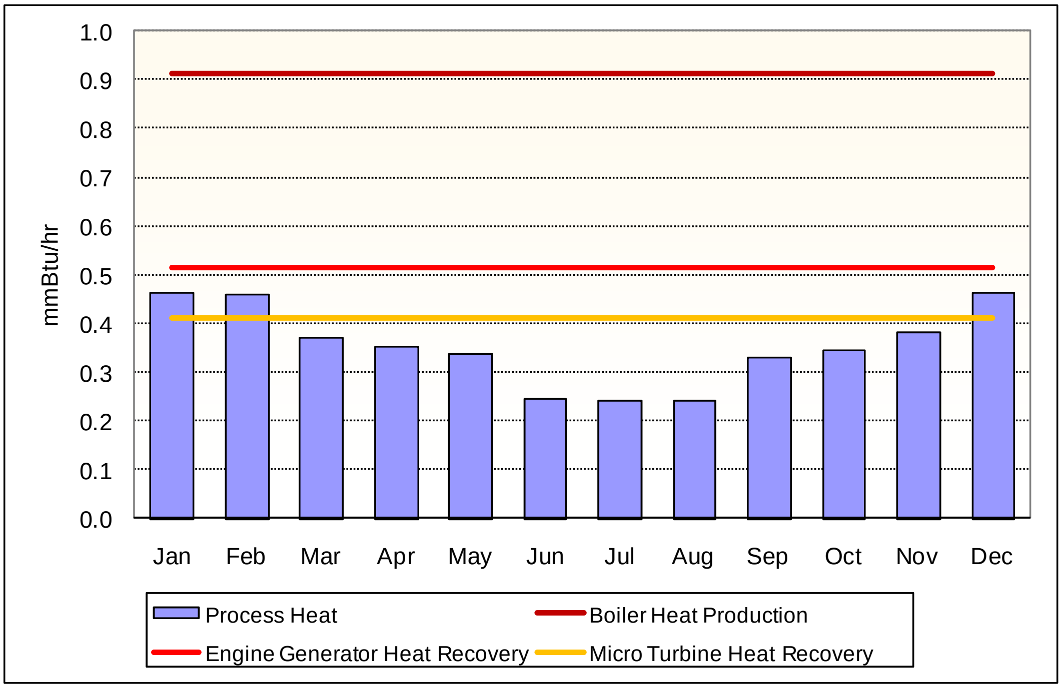

Figure 5.5 Digester Heating Requirement and Heat Recovery at Sundog WWTP

The results of the CHP waste heat vs. digester heating requirements for engine generators and MicroTurbines at the Centralized Airport WRF are presented on Figure 5.6. Similar to the results for the Sundog plant, waste heat from engine generators at the Centralized plant is expected to be adequate for digester heating under all monthly average conditions. However, waste heat from MicroTurbines is estimated to inadequate for digester heating during January, February, and December and will require purchase of supplemental natural gas.

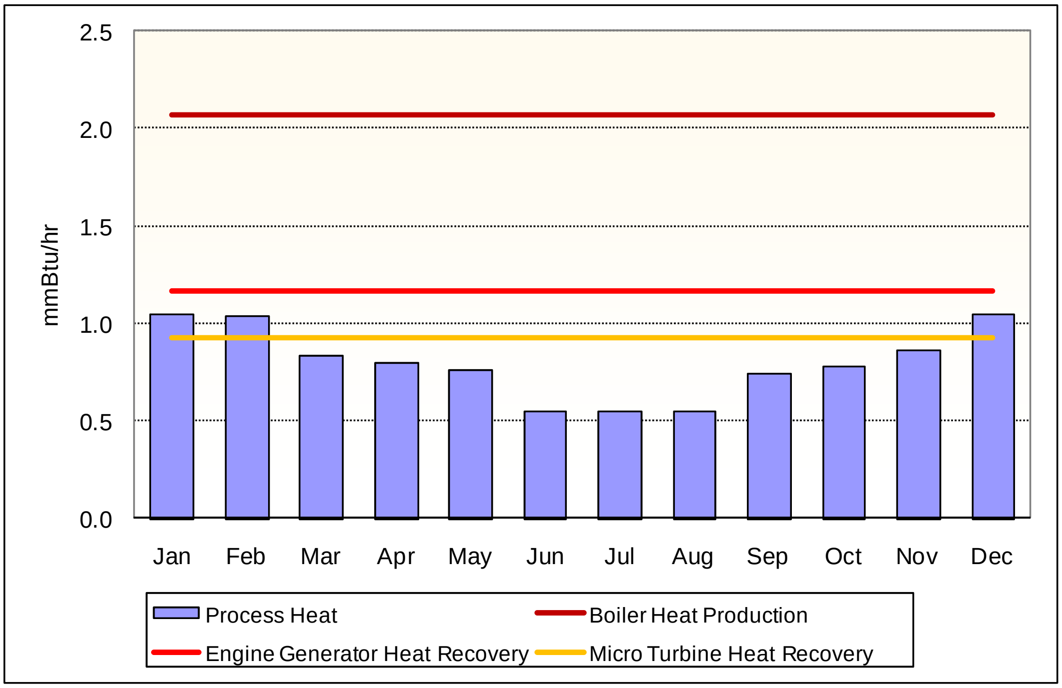

Figure 5.6 Digester Heating Requirement and Heat Recovery at Centralized Treatment Facility

5.5 Biogas Characteristics and Cleaning

Biogas is a by-product of the anaerobic digestion process. During digestion, the biodegradable fraction of the sludge volatile solids is converted to methane (CH_4) and carbon dioxide (CO_2). The biogas can also contain contaminants, including H_2S, particulates, and siloxanes. The gas is saturated with moisture at the temperature of the digester (95ºF, 35ºC). The heating value of the biogas is typically 600 Btu per cubic foot (Btu/cf), compared to about 1,000 Btu/cf for natural gas.

Biogas is typically generated at 8 to 10 in. w.c. pressure, enabling it to be collected from the digesters and conveyed via low-pressure piping to the secondary digesters, which provide both liquid and gas storage. Depending on the ultimate use of the biogas, compressors may be required to boost the gas pressure to approximately 5 psig or more. The pressurized gas may also be piped to a gas treatment facility to remove H_2S and siloxanes, and through a gas cooler or dryer to remove moisture before being used by boilers, engines, or MicroTurbines.

Gas cleaning requirements included in this evaluation are listed in Table 5.7. While siloxanes removal is included in this evaluation, requirements for their removal for the co-generation options should be further evaluated based on analysis of each plant's biogas.

Table 5.7 Biogas Cleaning Requirements Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona			
Cleaning Process	**Case 1 Digester Heat**	**Case 2 Engine Generators**	**Case 3 MicroTurbines**
Moisture removal	X	X	X
Compression	X	X	X
H_2S removal		X	X
Siloxanes removal		X	X

5.6 Cost Evaluation

Capital and operating costs for biogas utilization options are calculated for each of the biogas options described in Section 5.4. The following sections summarize cost factors, unit costs, and life cycle costs of this evaluation. Detailed cost information is presented in Appendix A.

Capital costs are presented as the additional capital cost to add engine generators, MicroTurbines and gas cleaning facilities. Since all options include digestion, no costs are included for boilers, heat exchangers, and other equipment required for digester heat. It is assumed that the gas cleaning system for the boiler option will be installed inside a digester control building. Gas cleaning system for the CHP options, which are in much bigger size because of the sulfur and siloxanes removal vessels, will be installed outdoors on a slab-on-grade, with a rain cover to shield the equipment. Engine generators will be installed outdoors on a slab–on-grade, with stainless steel enclosures to mitigate noise, and with a rain cover. The MicroTurbines are installed on a concrete slab, exposed to weather at the digester facility. Construction cost factors are listed in Table 5.8. No spare power generation equipment was provided for either CHP option.

Table 5.8 Construction and Design Cost Factors Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona	
Sitework	5%
Electrical and Instrumentation	12%
General Requirement	15%
Contingencies	30%
Engineering, Legal and Administration	15%

Annual costs are calculated as the annual operation and maintenance costs to supply digester heat and support the gas utilization options. Annual costs of Case 1 (boiler option) are limited to those associated with biogas cleaning for process use. For Case 2 and Case 3 (engine generator and MicroTurbine options, respectively) annual costs include costs for operating the power generation equipment, as well as for operating the gas cleaning systems. Maintenance costs include replacement media for gas cleaning and replacement parts for gas cleaning equipment. Maintenance costs for the engine generators or MicroTurbines include a maintenance contract based on a cost per kilowatt hour of power produced. This maintenance cost is estimated at $0.015 per kWh and $0.008 per kWh for the engine generators and MicroTurbines, respectively. Unit cost factors for annual costs are listed in Table 5.9.

Table 5.9 Construction and Design Cost Factors
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

Purchased natural gas	$10.9/mmBtu
Purchased electricity	$0.086/kWh
Maintenance materials	1% of capital
Labor	
Operation	$30.0/hr
Maintenance	$32.5/hr

Annual benefits assign value to the heat generated through biogas combustion, based on a boiler efficiency of 80 percent, and electrical power and heat produced through the co-generation options. The value of the process heat is based on the amount of purchased natural gas that would be required to produce a similar quantity of heat. The value of the recovered heat is limited to the process and/or building heating requirements. In this evaluation, excess heat has no value. Electricity produced by the co-generation options is valued at the City's purchase price of $0.086/kWh, using the assumption that 100 percent of the generated electricity can be used at the plant.

Present worth costs are calculated for the capital costs, annual costs and annual savings based on 20 year life, and 5 percent interest.

The summary of costs and benefits for biogas utilization at Sundog WWTP are presented in Table 5.10. The Centralized Airport WRF costs are presented in Table 5.11.

Table 5.10 Costs and Benefits for Digester Gas Utilization at Sundog WWTP
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Case 1 Digester Heat	Case 2 Engine Generators	Case 3 MicroTurbines
Installed Capacity	0.5 mmBtu/hr[1]	1[2] @ 132 kW 132 kWe	2[2] @ 65 kW 130 kWe
Annual Energy Benefit			
Thermal energy, mmBtu/yr	3,090[3]	3,090[4]	2,980[4]
Electricity, kWh/yr	0	1,039,000	772,000
Capital Cost, $			
Energy recovery	0[6]	337,000	532,000
Gas cleaning	200,000	693,000	808,000
Total	200,000	1,030,000	1,340,000
Annual Costs for Energy Recovery, $/year			
Electricity	0[5]	0	0
Labor	0[5]	21,000	19,000
Maintenance materials	0[5]	16,000	6,000
Total	0[5]	37,000	25,000
Annual Costs for Gas Cleaning, $/year			
Electricity	13,000	14,000	24,000
Labor	6,000	23,000	23,000
Maintenance materials	1,000	18,000	18,000
Total	20,000	55,000	65,000
Annual Benefits, $/year			
Electricity	0	(89,000)	(66,000)
Natural Gas Savings[6]	(33,000)	(33,000)	(32,000)
Present Worth Costs, $			
Capital Costs	200,000	1,030,000	1,340,000
Annual Costs	20,000	92,000	90,000
Annual Savings	(33,000)	(122,000)	(98,000)
Total Annual Cost (Savings)	(13,000)	(30,000)	(8,000)
PW Annual Cost (Savings)	(162,000)	(374,000)	(100,000)
PW Total Cost (Savings)	38,000	656,000	1,240,000
Annualized PW Cost	3,000	53,000	100,000
Annualized Unit Costs, $/kWh			
Electricity Generation[7]	NA[8]	0.136	0.214

[1]Required process heat capacity; not included in costs

[2]No spare capacity provided for CHP

[3]All digesters heated, additional gas flared

[4]All digester heat from CHP heat recovery

[5]Digester heat recovery equipment costs included in digester capital costs

[6]Heat recovery benefit limited to digester heat requirements

[7]Unit costs for electricity generation include capital and O&M costs for gas cleaning and CHP equipment, natural gas credits

[8]Not applicable

Table 5.11 Costs and Benefits for Digester Gas Utilization at Centralized Treatment Facility
Memorandum No. 9 – Biosolids Alternatives Evaluation
City of Prescott, Arizona

	Case 1 Digester Heat	Case 2 Engine Generators	Case 3 MicroTurbines
Installed Capacity	1.1 mmBtu/hr	2[2] @ 132 kW 264 kWe	3[2] @ 65 kW 195 kWe
Annual Energy Benefit			
Thermal energy, mmBtu/yr	6,970[3]	6,970[4]	6,720[4]
Electricity, kWh/yr	0	2,321,000	1,724,000
Capital Cost, $			
Energy recovery	0[6]	676,000	8611,000
Gas cleaning	530,000	894,000	1,049,000
Total	530,000	1,570,000	1,860,000
Annual Costs for Energy Recovery, $/year			
Electricity	0[5]	0	0
Labor	0[5]	25,000	20,000
Maintenance materials	0[5]	35,000	14,000
Total	0[5]	60,000	34,000
Annual Costs for Gas Cleaning, $/year			
Electricity	14,000	16,000	28,000
Labor	6,000	23,000	23,000
Maintenance materials	2,000	36,000	37,000
Total	22,000	75,000	88,000
Annual Benefits, $/year			
Electricity	0	(200,000)	(148,000)
Natural Gas Savings[6]	(74,000)	(74,000)	(71,000)
Present Worth Costs, $			
Capital Costs	530,000	1,570,000	1,860,000
Annual Costs	22,000	135,000	125,000
Annual Savings	(74,000)	(274,000)	(219,000)
Total Annual Cost (Savings)	(52,000)	(139,000)	(97,000)
PW Annual Cost (Savings)	(648,000)	(1,732,000)	(1,208,000)
PW Total Cost (Savings)	(118,000)	(162,000)	652,000
Annualized PW (Savings)	(9,000)	(13,000)	52,000
Annualized Unit Costs, $/kWh			
Electricity Generation[7]	NA[8]	0.081	0.116

[1]Required process heat capacity; not included in costs

[2]No spare capacity provided for CHP

[3]All digesters heated, additional gas flared

[4]All digester heat from CHP heat recovery

[5]Digester heat recovery equipment costs included in digester capital costs

[6]Heat recovery benefit limited to digester heat requirements

[7]Unit costs for electricity generation include capital and O&M costs for gas cleaning and CHP equipment, natural gas credits

[8]Not applicable

5.7 Conclusions and Recommendations

Life cycle costs evaluation for the Sundog WWTP shows that the total present worth cost of the three biogas utilization alternatives are $38,000, $656,000, and $1,240,000, respectively, meaning that no cost savings are projected. Based on the results of this evaluation, on-site power generation is not cost effective and is therefore not recommended for the Sundog WWTP. Typically, on-site power generation is not cost effective for treatment plants with influent flows of less than 10 to 15 mgd, unless additional funding or power offsets are available. However, use of biogas for digester heating eliminates the need for natural gas purchases and consequently, the impacts of fluctuating natural gas prices on plant O&M costs. There is considerable potential savings with this approach. In fact, the City reports that by switching to digester gas for sludge heating, they are currently saving about $63,000 per year.

Based on the lifecycle costs of the gas utilization options at the Centralized Airport WRF, on-site power generation using engine generators may be cost effective. As shown in Table 5.11, the present worth cost savings for the digester heating and engine generator biogas utilization options are $118,000 and $162,000 respectively. The lifecycle costs for MicroTurbines (Case 3) are higher than for engine generators due to their higher capital costs and lower power generation efficiencies and no cost savings are projected. It is noted that MicroTurbines also have lower emissions than engine generators and this could be important if air emissions are critical. Based on the results of this evaluation, on-site power generation using engine generators is recommended for future consideration at Centralized Airport WRF when the capital cost of the facilities is not constrained by funds availability in the City's CIP. If future emission restrictions at the Centralized Airport WRF require advanced emission control for engine generators, Case 2 capital and O&M costs will increase significantly. Costs for advanced emission control for the engine generators (Case 2) are not included in this evaluation. It should be noted that this evaluation was based on a 6 mgd combined flow; at lower flows, the plant will produce less electricity and the unit generation cost will be higher than listed herein.

The estimated costs presented in this evaluation are based on a constant cost of natural gas and electricity, and do not include cost escalators. Increases in power costs will make on-site generation options more attractive. For instance, the unit cost for electricity generation at the Centralized Airport WRF is $0.081/kWh using engine generators and $0.116/kWh using MicroTurbines based on the City paying $0.086/kWh for purchased electricity. As the electricity cost increases, the benefits of on-site power generation will increase. At the point when the electricity cost exceeds $0.116/kWh, using Microturbines could be cost effective as well.

If on-site power generation is installed at the Centralized Airport WRF, the biogas cleaning and CHP system should be designed to allow for future expansion, as the Centralized Airport WRF flows increase to the ultimate capacity of 15 mgd. It is also recommended that biogas should be sampled and analyzed for contaminants prior to system design to determine actual biogas cleaning requirements.

6.0 REGIONAL BIOSOLIDS MANAGEMENT

As part of this project, the team discussed the possibilities/opportunities for a regional biosolids handling facility, which could process and provide beneficial end use of biosolids from a variety of surrounding communities, including the City of Prescott. In the context of a larger regional facility, the potential application of certain technologies becomes significantly more viable as capital and O&M costs can be partially offset by factors including economics of scale and cogeneration opportunities.

Contributing communities could share the fiscal responsibility for construction and operation, thereby reducing the burden on the individual communities. In addition, the resulting high quality biosolids could be redistributed within the participating communities on community-owned parks and golf courses, or could potentially be marketed to outside agencies or the general public - providing a sustainable market for the beneficial end use product. Based on these factors, the possibility of a regional biosolids handling facility was evaluated, on a cursory level, as a potential long-term biosolids management strategy.

The regional biosolids handling facility concept would require the participation of various entities including local land appliers, commercial composting companies, permitting authorities such as the Arizona Department of Environmental Quality (ADEQ) and the Yavapai and Coconino Counties' Zoning and Planning Commissions. The Northern Arizona Council of Governments (NACOG) may also be a potential third party coordinator in this endeavor. Most importantly, a regional biosolids handling facility would require the participation of the surrounding communities. Per the request of the City, each of these groups was contacted to evaluate the current conditions of biosolids land application in Yavapai and Coconino Counties. Ultimately, the goal of this preliminary effort was to gain insight regarding the interest in a regional biosolids handling facility and to identify initial potential obstacles (including required permitting efforts) for implementation of a regional facility.

6.1 Contract Land Appliers

Privately owned land application companies can be contracted to haul biosolids to land application site or to landfills. The benefit of contracting with a private land applier is the company bears the responsibility of tracking the quantity of biosolids land applied/disposed and reporting to the ADEQ.

Previously, Southwest Land Reclamation (SLR) was the company which handled the majority of biosolids land application in Yavapai County, maintaining contracts with eight different farms throughout Yavapai County as well as the Grey Wolf Landfill in the event that any of the farms are unavailable for land application. SLR is no longer in operation, however, prior to ceasing operations the owner of SLR expressed that the market for Class B biosolids is decreasing due to the decrease in available agricultural land. SLR's owner also noted that the market may move toward land application on federal lands (i.e., US Forest Services areas), which would require coordination with federal organizations. In the past SLR had considered implementation of a regional composting facility. However, obtaining a continuous carbon source to promote effective operation was problematic.

After the closing of SLR, D&K Farming Enterprises (D&K) took over several of SLR's existing contracts. Like SLR, D&K accepts both dewatered Class A and B quality biosolids for land application. Contract terms may vary, but generally, cost to landfill is approximately $45 per ton, while land application is at least one third less than landfilling.

D&K currently is open to accepting new contracts for biosolids management and has sufficient area for land application through contracts with the various farms in the vicinity of Northern Arizona.

Because of their vast experience and knowledge of land application in Yavapai County, D&K could be an important contributor if the City and the surrounding communities wish to pursue the concept of a regional biosolids handling facility.

6.2 Arizona Soils Composting and Eden Organics

Arizona Soils Composting (ASC) is the only permitted and operating commercial composting facility in the State of Arizona. It is owned and operated by Synagro and is located in Vicksburg, Arizona, approximately 100 miles south and west of Prescott. ASC accepts approximately 200 tons per day of sludge, dewatered to 20% solids content, from California municipalities. They currently do not have any contracts in place with Arizona municipalities, but would be interested in accepting sludge from local communities. ASC produces Class A biosolids, which Synagro land applies at local farms, golf courses, nurseries, baseball fields, etc. Synagro bears the responsibility of land application of the end product and any permitting required through ADEQ and La Paz County.

Costs associated with composting unstabilized sludge with ASC varies based on hauling distance. However, based on preliminary estimates, hauling sludge approximately 100 miles from Prescott to the existing composting site would cost approximately $55 per wet ton, plus hauling surcharges.

Due to their significant experience in the commercial composting industry, Synagro could be an important contributor if the City and the surrounding communities wish to pursue the concept of a regional biosolids handling facility - particularly if there is an interest in composting.

In addition to ASC, there is a second commercial composting facility in the State of Arizona - Eden Organics. The facility, which is located 9 miles northeast of Flagstaff, Arizona, is not currently in operation because it was not granted the required zoning permits needed to operate by Coconino County. Based on this experience, it should be noted that the success of a regional biosolids handling project would rely heavily on the support and cooperation of Yavapai County.

6.3 County Agencies

As noted above, the successful implementation of a regional biosolids handling facility in Yavapai or Coconino Counties would require the support and cooperation of local governing authorities.

6.3.1 Yavapai County Planning and Zoning Commission

The Yavapai County Planning and Zoning Department was contacted to gain understanding regarding the requirements for implementing the proposed facility. Preliminary conversations with Yavapai County revealed that a facility of this type would require a use permit. In order to acquire a use permit, the proposal for the facility must go through two public hearings, overseen by the Yavapai County Planning and Zoning Commission and the Board of Supervisors. Following acceptance by these two entities, the proposal must then be reviewed by the Yavapai County Environmental Health Services Department as well as ADEQ.

The Planning and Zoning Commission would review a detailed report prepared for the hearing, including information about the project, the purpose of the facility, and citizen participation efforts. In conversations with the County, it appeared that the most important factor in gaining approval of the Commission and Board is the level of effort in citizen participation. Citizen participation involves public outreach and education efforts to inform the community of the proposal, and gauge the initial reaction of the surrounding community. The objective is to address the concerns of the public regarding the proposed location, its potential affect on the aquifer below, etc. If overwhelming opposition by the public exists, the Commission will consider this factor heavily in its decision. Therefore, it is critical to obtain public acceptance to assist in obtaining the approval of the Commission and Board of Supervisors.

6.3.2 Coconino County Planning and Zoning Commission

The Coconino County Planning and Zoning Commission was also contacted to gain insight into the requirements for implementing a regional biosolids handling facility in the area. Preliminary conversations with the Coconino County Planning and Zoning Commission indicated that the requirements may vary depending on the potential location of the facility. Depending on the surrounding land use and the transportation around the area, different entities may be involved. The Board of Supervisors may have to initiate re-zoning criteria and the County Health Department will need to be involved as well.

Regardless of the location of the facility, public hearings and citizen participation will play a significant role. A pre-application meeting will identify specific entities and individuals who will need to be notified as to the future facility.

More detailed information regarding the approval process from the County cannot be identified until more information regarding the proposed facility is available. Therefore, it is recommended that the County not be involved until coordination with the communities to move forward with siting a location for the facility has been completed.

6.4 Local Communities

Communities in northern Arizona were contacted to gain insight regarding their current biosolids treatment and disposal strategies. In addition, each community's interest in a regional facility was gauged, and a local market for EQ and Class A biosolids was established. The information gathered from this scoping effort is summarized herein. Figure 6.1 presents the locations of the various communities contacted.

Figure 6.1 Cities Contact for Biosolids Treatment and Disposal Strategies

6.4.1 City of Flagstaff

The City of Flagstaff is located in Coconino County, northeast of Yavapai County. The City of Flagstaff has two treatment facilities, the Wildcat Hill Wastewater Treatment Plant (6 mgd capacity), and the Rio de Flag Wastewater Reclamation Plant (4 mgd capacity).

The Rio de Flag WRP produces primary sludge and waste activated sludge from its treatment processes (primary sedimentation and activated sludge process). The solids produced at the Rio de Flag WRP are sent via the collection system to the Wildcat Hill WWTP for further processing and treatment.

The Wildcat Hill WWTP also produces primary sludge and waste activated sludge from primary sedimentation and an integrated fixed film activated sludge process, in addition to the solids received from the Rio de Flag WRP. The Wildcat Hill WWTP employs anaerobic digestion and stabilization ponds to produce a Class B quality biosolids slurry. The stabilized biosolids slurry is subsurface injected on a 40-acre site, which is part of the plant property. Plant staff estimates that 1,000 tons of sludge are injected annually.

City staff and residents have a general interest on green technologies and sustainable practices. There have been some discussions regarding landfill disposal for composting with green waste. City staff expressed a general interest in the possibility of in a regional biosolids approach that would offer beneficial use of biosolids.

6.4.2 City of Sedona

The City of Sedona is located at the border of Yavapai and Coconino Counties. The Sedona Wastewater Reclamation Plant (WWRP) currently treats approximately 1.2 mgd of wastewater. The ultimate build-out capacity of the Sedona WWRP is 2.0 mgd. However, the timeframe for build-out is unknown, and the flow anticipated in the foreseeable future will be approximately 1.5 to 1.6 mgd.

The Sedona WWRP currently utilizes conventional secondary treatment. Wasted sludge is digested for approximately 10 days and then dewatered in either air drying beds or centrifuges to 20 percent solids content. Because the solids are not treated to Class A or B quality, they are sent to a landfill for disposal. Approximately 1,500 tons of solids per year are currently sent to the landfill for disposal. It is anticipated that at the ultimate build-out of 2.0 mgd plant capacity approximately 2,500 tons of dewatered solids per year will be generated for disposal (based on a linear extrapolation of current and future influent flow).

The City of Sedona has expressed interest in the concept of a regional biosolids handling facility and the Class A biosolids could be utilized on parks within the City and distributed/sold to citizens.

6.4.3 Town of Prescott Valley

The Town of Prescott Valley is located northeast of the City of Prescott. The Prescott Valley wastewater treatment plant currently treats approximately 2.4 to 2.5 mgd of wastewater, although its rated treatment capacity is 3.75 mgd. The ultimate buildout capacity is anticipated to be approximately 7.5 mgd, but the timeframe for this expansion is unknown as they are still approximately 10 to 15 years away from reaching the current rated capacity.

The Prescott Valley wastewater treatment plant utilizes conventional secondary treatment. The secondary clarifier wastes to a holding basin prior to dewatering to 15 percent solids with a belt filter press. Previously, the biosolids met Class B quality standards via testing, and Prescott Valley maintained a contract with SLR for approximately 5 years to land apply biosolids. However, the contract expired in 2008, and the Town chose not to renew.

Prescott Valley then disposed of biosolids at the Grey Wolf Landfill, however, tipping fees became cost prohibitive and the solids were then sent to a landfill near Phoenix. Prescott Valley disposes of approximately 4,500 to 5,000 tons per year of dewatered biosolids at tipping and hauling fees of $38 per ton. At the plant's ultimate build-out of 7.5 mgd, approximately 15,000 tons per year of dewatered biosolids could potentially be generated (based on a linear extrapolation of current and future influent flow).

Prescott Valley expressed an interest in participating in a discussion regarding a regional biosolids handling facility, but noted that they were unlikely to take the initiative to begin the collaboration. They also noted that the private sector may be best positioned for coordinating an endeavor of this magnitude.

6.4.4 Town of Camp Verde

The Town of Camp Verde is located approximately 40 miles east of the City of Prescott. The Camp Verde Sanitary District recently constructed a wastewater treatment plant that was brought online in the fall of 2009. The WWTP is rated for 6.5 mgd, but is currently treating approximately 2.0 mgd of wastewater. It is anticipated that the plant will not reach capacity for 10 to 15 years.

The Camp Verde Sanitary District WWTP is equipped with conventional secondary treatment. Wasted sludge from the secondary clarifier is mechanically dewatered with a belt filter press and the dewatered sludge is sent to disposal at the Grey Wolf Landfill. It is estimated that the Camp Verde Sanitary District spends approximately $8,400 per month in disposal fees for the biosolids produced at the WWTP.

The Camp Verde Sanitary District has expressed interest in the concept of a regional biosolids handling facility in the future.

6.4.5 Town of Chino Valley

The Town of Chino Valley is located just north of the City of Prescott. Unlike other communities in the area, the Chino Valley Water Resources Department does not have a conventional activated sludge wastewater treatment plant. Chino Valley constructed a Membrane Bio-Reactor (MBR) plant in 2004. The current plant capacity is approximately 350,000 gallons per day (gpd) and is expected to expand to 1,000,000 gpd in the future.

The wastewater treatment facilities do not include sludge stabilization processes. Waste activated sludge from the MBR process is dewatered in a belt filter press for landfill disposal.

6.4.6 Town of Clarkdale

The Town of Clarkdale is located northeast of the City of Prescott. The Town's existing wastewater treatment is achieved in a secondary treatment lagoon system, which currently treats approximately 120,000 to 140,000 gallons per day. The current treatment facilities have a capacity of 250,000 gallons per day, and the Town has plans to expand their treatment capacity to 600,000 gallons per day in the future.

Biosolids from the lagoon system are periodically removed from the system, but unlike conventional activated sludge systems, biosolids are not removed from the system on a daily basis. In the future, the Town expressed interest in exploring land application and composting as potential biosolids disposal alternatives.

6.4.7 City of Prescott

The City of Prescott has two wastewater treatment facilities, the Airport WRF and the Sundog WWTP. The Airport WRF currently employs an activated sludge treatment process, generating waste activated sludge. The Sundog WWTP has primary and secondary treatment facilities and produces both primary sludge and waste activated sludge.

Currently, the Airport WRF does not have sludge stabilization facilities, and the dewatered waste activated sludge is sent to landfill disposal. The Sundog WWTP employs anaerobic digestion and currently produces Class B biosolids, which are normally disposed of via land application. The City currently has a contract with D&K for the transport and disposal of the biosolids from the two treatment facilities.

The City has expressed interest in the concept of a regional biosolids handling facility, and is interested in exploring the possible synergies that can result from a regional biosolids handling approach. The City recognizes that such an approach may become more feasible in the long term, when all the potential participants generate sufficient biosolids to make a regional facility cost-effective for all the parties involves.

6.5 Summary

As discussed, the successful implementation of a regional biosolids handling facility would depend heavily on the collaboration of various organizations, governing authorities, and local communities. Each group would play a significant role in the coordination of the project. Because D&K has taken over as the primary biosolids land applier in the region, they could provide valuable insight into the local practice of land application, the local need for biosolids, and the required permitting efforts. Should a regional facility include composting as the biosolids stabilization technology, Synagro could provide valuable information regarding facility operation and permitting efforts, as they currently own the only operating commercial composting facility in the State of Arizona. Per the Yavapai and Coconino Counties' Planning and Zoning Commissions, citizen participation will also play a crucial role in gaining approval for a regional biosolids handling facility. Extensive public outreach and education must occur to garner the support of local residents and address any concerns regarding the location of the proposed facility and its long-term affect on the environment. In addition, the participation of local municipalities will be a critical success factor for a regional biosolids handling facility. Currently four of the local communities outside of Prescott have expressed interest in a regional biosolids handling facility project. Without the commitment of a majority of the communities to treat their undigested sludge at the regional facility, implementation of the facility may not be economically justifiable. Table 6.1 provides a summary of the various communities contacted during this evaluation, their current and anticipated solids production as well as the general interest in a regional facility.

Table 6.1 Summary of Potential Regional Facility Community Participants Technical Memorandum No. 9 – Biosolids Alternatives Evaluation City of Prescott, Arizona

Community	Current Biosolids Management Practice	Current Biosolids Production (wet tons/ year)	Estimated Future Biosolids Production (wet tons/year)	Potential Interest in Regional Facility?
City of Flagstaff	Subsurface injection Class B biosolids	1,000 [(1)]	N.A.	Yes
City of Sedona	Landfill dewatered sludge	1,500	2,500	Yes
Town of Prescott Valley	Landfill Class B biosolids	4,500 - 5,000	15,000	Yes
Town of Camp Verde	Landfill dewatered sludge	N.A.	N.A.	Yes
Town of Chino Valley	Landfill dewatered sludge	274	1,100	N.A.
Town of Clarkdale	Landfill disposal of lagoon sludge	N.A.	N.A.	N.A.
City of Prescott	Land application Class B biosolids, and landfill dewatered sludge	4,490	21,800	Yes

Notes:
(1) To be confirmed
N.A. = Not available at the time the report was issued.

The implementation of a regional biosolids handling facility in Yavapai or Coconino Counties will require significant collaboration of various groups and organizations. The coordination effort for a project with so many participants will likely take years to implement. While a regional biosolids handling facility will likely not come to fruition in the near-term, it could provide a viable long-term biosolids management alternative. However, making the facility a reality will require a dedicated and vested “champion” to coordinate the many stakeholders and further define the opportunities and potential roadblocks for implementation.

7.0 CONCLUSIONS

7.1 Biosolids Disposal and Reuse

The City currently practices land application on agricultural land with Class B biosolids from the Sundog WWTP. Unclassified biosolids from the Airport WRF are currently disposed of at a landfill. Maintaining these disposal and reuse practices represents the most cost-effective near-term strategy for the City. In the long-term, landfill disposal costs may increase and it will likely be cost effective to implement Class B biosolids stabilization facilities at the Airport WRF. If hauling costs increase dramatically, alternatives that significantly reduce the volume for disposal/reuse, such as thermal drying or biosolids-to-energy may become viable.

7.2 Biosolids Stabilization

For the near-term and long-term, continued anaerobic digestion is recommended for the Sundog WWTP. At the Airport WRF, continued dewatering and hauling of non-stabilized solids is recommended in the near-term. As the Airport WRF grows in size (5-10 mgd) and the costs for landfilling of unclassified biosolids increases, it is recommended that the City implement anaerobic digestion for Class B biosolids stabilization. If centralized treatment at the Airport WRF is implemented, anaerobic digestion is recommended for the near-term and long-term to achieve Class B biosolids. Should a regional biosolids facility becomes a reality, alternatives to achieve Class A biosolids such as composting, thermal drying, and biosolids-to-energy should be evaluated.

7.3 Biogas Utilization

Continued use of biogas for digester heating at the Sundog WWTP is recommended. The City reports that they are saving approximately $63,000 per year in operating costs by eliminating natural gas heating of the digesters. Currently, on-site power generation is not cost-effective at the Sundog WWTP, unless grants or subsidies are available. If centralized treatment at the Airport WRF is implemented, on-site power generation will likely be cost effective when the treatment plant wastewater flow reaches approximately 5 mgd. Finally, if electrical power costs increase significantly, on-site power generation should be further evaluated for the Sundog WWTP or the Airport WRF (when anaerobic digestion is implemented at that facility).

7.4 Regional Biosolids Management

There does not appear to be an immediate opportunity for regional biosolids management given the need for significant collaboration between multiple organizations. The City should maintain contact with potential partners in the region, to determine if a regional biosolids facility would be practical and economical in the long-term. There may also be potential public-private partnership opportunities in the future with a regional solution to biosolids management.

Appendix A
Digester Gas Utilization – Cost Analysis

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
Title:	**Cost Summary of Digester Gas Utilization**	Date:	June 21, 2010
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Case 1: Boiler

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	0	cy	$700	
Canopy	0	sqft	$35	
Gas Cleaning Equipment Package[1]	1	LS	$75,000	$75,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$24,000	$24,000
Subtotal - Gas Cleaning				***$100,000***
Subtotal				$100,000
Total Capital Costs				$100,000
Sitework	5%			$5,000
Electrical and Instrumentation	12%			$12,000
HVAC & Plumbing	5%			$5,000
Contingencies	30%			$30,000
Contruction Subtotal				$150,000
CM Services, General Conditions	15%			$23,000
Engineering, Legal & Administration	15%			$23,000
Total Project Cost				**$200,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$13,000	$13,000
Labor				
Operations	1	LS	$0	$0
Maintenance	1	LS	$6,000	$6,000
Media Replacement	1	LS	$0	$0
Yearly Cost for Maintenance Equipment	1	1%	$800	$1,000
Subtotal - Gas Cleaning				***$20,000***
Natural Gas Credit				($33,000)
Total Operating Cost				**($13,000)**

PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$200,000
Total PW Capital Costs (Includes SV)	$200,000
Present Worth Cost of Annual O&M	($162,000)
Total Present Worth Costs	**$38,000**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	$3,000
Annual Average Gas Production (scf/yr)	16,878,000
Annualized Unit Cost ($/scf)	***$0.000***

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
Title:	**Cost Summary of Digester Gas Utilization**	Date:	June 21, 2010
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Case 2: Engine Generators

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	11	cy	$700	$8,000
Canopy	300	sqft	$35	$11,000
Gas Cleaning Equipment Package[1]	1	LS	$248,600	$249,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$76,000	$76,000
Subtotal - Gas Cleaning				***$350,000***
Cogeneration Facility				
Total Power Generation	119	kWh/hr		
Canopy	300	sqft	$35	$11,000
Overhead Crane	1	ea	$5,000	$5,000
Engine Gen and Heat Recovery System	1	*ea*	$107,000	$107,000
Engine Generator Enclosure	1	*ea*	$24,000	$24,000
Booster compressor package		Included with Gas Cleaning System		
Equipment Installation	1	20%	$27,000	$27,000
Subtotal - Cogeneration Facility				***$170,000***
Subtotal				**$520,000**
Total Capital Costs				$520,000
Sitework	5%			$26,000
Electrical and Instrumentation	12%			$62,000
HVAC & Plumbing	5%			$26,000
Contingencies	30%			$160,000
Contruction Subtotal				$790,000
CM Services, General Conditions	15%			$119,000
Engineering, Legal & Administration	15%			$119,000
Total Project Cost				**$1,030,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$14,000	$14,000
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$7,000	$7,000
Media Replacement	1	LS	$15,000	$15,000
Yearly Cost for Maintenance Equipment	1	1%	$2,540	$3,000
Subtotal - Gas Cleaning				***$55,000***
Congeneration Facility				
Power	1	LS	$0	--
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$5,000	$5,000
Yearly Cost for Maintenance Equipment		$/kW	$0.015	$16,000
Subtotal - Cogeneration				***$37,000***
Natural Gas Credit				($33,000)
Total Operating Cost				**$59,000**
Credit for Power Produced		$/kW	$0.086	($89,000)

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
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PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$1,030,000
Total PW Capital Costs (Includes SV)	$1,030,000
Present Worth Cost of Annual O&M	**$735,000**
Present Worth Cost of Generated Power	**($1,109,000)**
Total Present Worth Costs	**$656,000**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	$53,000
Annual Average Gas Production (scf/yr)	16,878,000
Annualized Unit Cost ($/scf)	***$0.003***
Annual Average Electricity Production (kW-h/yr)	1,039,000
Annualized Unit Cost ($/kWh)	***$0.136***

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
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Case 3: Microturbines

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	11	cy	$700	$8,000
Canopy	300	sqft	$35	$11,000
Gas Cleaning Equipment Package[1]	1	LS	$293,100	$293,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$89,000	$89,000
Subtotal - Gas Cleaning				***$410,000***
Cogeneration Facility				
Total Power Generation	88	kWh/hr		
Canopy	300	sqft	$35	$11,000
Overhead Crane	1	ea	$5,000	$5,000
Microturbine and Heat Recovery System	2	ea	$107,200	$214,000
Booster compressor package		Included with Gas Cleaning System		
Equipment Installation	1	20%	$44,000	$44,000
Subtotal - Cogeneration Facility				***$270,000***
Subtotal				$680,000
Total Capital Costs				$680,000
Sitework	5%			$34,000
Electrical and Instrumentation	12%			$82,000
HVAC & Plumbing	5%			$34,000
Contingencies	30%			$200,000
Contruction Subtotal				$1,030,000
CM Services, General Conditions	15%			$155,000
Engineering, Legal & Administration	15%			$155,000
Total Project Cost				**$1,340,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$24,000	$24,000
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$7,000	$7,000
Media Replacement	1	LS	$15,000	$15,000
Yearly Cost for Maintenance Equipment	1	1%	$2,980	$3,000
Subtotal - Gas Cleaning				***$65,000***
Congeneration Facility				
Power	1	LS	$0	--
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$3,000	$3,000
Yearly Cost for Maintenance Equipment		$/kW	$0.008	$6,000
Subtotal - Cogeneration				***$25,000***
Natural Gas Credit				($32,000)
Total Operating Cost				**$58,000**
Credit for Power Produced		$/kW	$0.086	($66,000)

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
Title:	**Cost Summary of Digester Gas Utilization**	Date:	June 21, 2010
		Page:	of

PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$1,340,000
Total PW Capital Costs (Includes SV)	$1,340,000
Present Worth Cost of Annual O&M	**$723,000**
Present Worth Cost of Generated Power	**($823,000)**
Total Present Worth Costs	**$1,240,000**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	$100,000
Annual Average Gas Production (scf/yr)	16,878,000
Annualized Unit Cost ($/scf)	***$0.006***
Annual Average Electricity Production (kW-h/yr)	772,000
Annualized Unit Cost ($/kWh)	***$0.214***

DO NOT WRITE IN THIS SPACE

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
Title:	**Power Costs**	Date:	June 21, 2010
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POWER USE AND COST

Unit Cost for Power (per kWh) $0.086

Case 1: Boilers

Equipment List	No. of Units	Installed HP	Operating HP	Hr/Day	Day/Wk	Wk/Yr	kWh/Yr	Cost $/yr
Sundog WWTP								
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	2	1.6	24	7	52	13,034	$1,121
Chilling Unit	1	15	12.0	24	7	52	97,756	$8,407
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**156,409**	**$13,000**

Case 2: Engine Generators

Equipment List	No. of Units	Installed HP	Operating HP	Hr/Day	Day/Wk	Wk/Yr	kWh/Yr	Cost $/yr
Sundog WWTP								
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	3	2.4	24	7	52	19,551	$1,681
Chilling Unit	1	15	12.0	24	7	52	97,756	$8,407
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**162,926**	**$14,000**

Case 3: Microturbines

Equipment List	No. of Units	Installed HP	Operating HP	Hr/Day	Day/Wk	Wk/Yr	kWh/Yr	Cost $/yr
Sundog WWTP								
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	20	16.0	24	7	52	130,341	$11,209
Chilling Unit	1	15	12.0	24	7	52	97,756	$8,407
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**273,716**	**$24,000**

Owner:	City of Prescott		Computed By:	YQ
Plant:	Sundog WWTP		Date:	June 4, 2010
PN:	164890.000	File No.	Checked By:	PAS
Title:	**Labor Costs**		Date:	June 21, 2010
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D O   N O T   W R I T E   I N   T H I S   S P A C E

LABOR REQUIREMENT AND COSTS

Operation Labor	$30.0
Maintenaince Labor	$32.5

Case 1: Boilers

Sundog WWTP								
Labor Category	**Number**	**Hr/Shift**	**Shift/Day**	**Day/Wk**	**Wk/Yr**	**Total Hours**	**Hourly Rate**	**Cost, $/yr**
Gas Cleaning								
Operation	0	0.5	3.0	7	52	0	$30.0	0
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	0	8	1.0	4	1	0	$32.5	0
Subtotal						**182**		**$6,000**

Case 2: Engine Generators

Sundog WWTP								
Labor Category	**Number**	**Hr/Shift**	**Shift/Day**	**Day/Wk**	**Wk/Yr**	**Total Hours**	**Hourly Rate**	**Cost, $/yr**
Gas Cleaning								
Operation	1	0.5	3.0	7	52	546	$30.0	16,000
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	1	8	1.0	4	1	32	$32.5	1,000
Subtotal						**760**		**$23,000**
Engine Generators								
Operation	1	0.5	3.0	7	52	546	$30.0	16,380
Maintenance (general)	1	0.3	1.0	7	52	109	$32.5	3,549
Maintenance (other)	1	8	1.0	4	1	32	$32.5	1,040
Subtotal						**687**		**$21,000**

Case 3: Microturbines

Maintenance (general)								
Labor Category	**Number**	**Hr/Shift**	**Shift/Day**	**Day/Wk**	**Wk/Yr**	**Total Hours**	**Hourly Rate**	**Cost, $/yr**
Gas Cleaning								
Operation	1	0.5	3.0	7	52	546	$30.0	16,000
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	1	8	1.0	4	1	32	$32.5	1,000
Subtotal						**760**		**$23,000**
Microturbines								
Operation	1	0.5	3.0	7	52	546	$30.0	16,380
Maintenance (general)	1	0.15	1.0	7	52	55	$32.5	1,775
Maintenance (other)	1	8	1.0	4	1	32	$32.5	1,040
Subtotal						**633**		**$19,000**

Owner:	City of Prescott		Computed By:	YQ
Plant:	Sundog WWTP		Date:	June 4, 2010
PN:	164890.000	File No.	Checked By:	PAS
Title:	**Nature Gas Costs**		Date:	June 21, 2010
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D O N O T W R I T E I N T H I S S P A C E

NATURAL GAS COSTS

Natural Gas Cost ($/mmBtu) $10.60

Case 1: Boilers

Sundog WWTP								
Month	Day/Month	Digester Heat Rqrmt	Heat Available	Nature Gas	Credits		Unit Price ($/mmBtu)	Cost ($/yr)
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	0.46	0.91	0.00	0.46	345.8		
February	28	0.46	0.91	0.00	0.46	308.8		
March	31	0.37	0.91	0.00	0.37	274.9		
April	30	0.35	0.91	0.00	0.35	254.9		
May	31	0.34	0.91	0.00	0.34	252.9		
June	30	0.24	0.91	0.00	0.24	175.7		
July	31	0.24	0.91	0.00	0.24	180.8		
August	31	0.24	0.91	0.00	0.24	180.8		
September	30	0.33	0.91	0.00	0.33	238.5		
October	31	0.35	0.91	0.00	0.35	257.2		
November	30	0.38	0.91	0.00	0.38	276.4		
December	31	0.46	0.91	0	0.46	345.8		
Total				mmBtu/yr		3,092	$ 10.60	($33,000)

Case 2: Engine Generators

June								
Month	Day/Month	Digester Heat Rqrmt	Heat Available	Nature Gas	Credits		Unit Price ($/mmBtu)	Cost ($/yr)
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	0.46	0.51	0.00	0.46	345.8		
February	28	0.46	0.51	0.00	0.46	308.8		
March	31	0.37	0.51	0.00	0.37	274.9		
April	30	0.35	0.51	0.00	0.35	254.9		
May	31	0.34	0.51	0.00	0.34	252.9		
June	30	0.24	0.51	0.00	0.24	175.7		
July	31	0.24	0.51	0.00	0.24	180.8		
August	31	0.24	0.51	0.00	0.24	180.8		
September	30	0.33	0.51	0.00	0.33	238.5		
October	31	0.35	0.51	0.00	0.35	257.2		
November	30	0.38	0.51	0.00	0.38	276.4		
December	31	0.46	0.51	0.00	0.46	345.8		
Total				mmBtu/yr		3,092	$ 10.60	($33,000)

Owner:	City of Prescott	Computed By:	YQ
Plant:	Sundog WWTP	Date:	June 4, 2010
PN:	164890.000 File No.	Checked By:	PAS
Title:	**Nature Gas Costs**	Date:	June 21, 2010
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Case 3: Microturbines

September								
Month	Day/Month	Digester Heat Rqrmt	Heat Available	Nature Gas	Credits		Unit Price ($/mmBtu)	Cost ($/yr)
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	0.46	0.41	0.05	0.41	305.3		
February	28	0.46	0.41	0.05	0.41	275.8		
March	31	0.37	0.41	0.00	0.37	274.9		
April	30	0.35	0.41	0.00	0.35	254.9		
May	31	0.34	0.41	0.00	0.34	252.9		
June	30	0.24	0.41	0.00	0.24	175.7		
July	31	0.24	0.41	0.00	0.24	180.8		
August	31	0.24	0.41	0.00	0.24	180.8		
September	30	0.33	0.41	0.00	0.33	238.5		
October	31	0.35	0.41	0.00	0.35	257.2		
November	30	0.38	0.41	0.00	0.38	276.4		
December	31	0.46	0.41	0.05	0.41	305.3		
Total				**mmBtu/yr**		**2,979**	**$ 10.60**	**($32,000)**

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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Case 1: Boiler

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	0	cy	$700	
Canopy	0	sqft	$35	
Gas Cleaning Equipment Package[1]	1	LS	$200,000	$200,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$62,000	$62,000
Subtotal - Gas Cleaning				***$270,000***
Subtotal				$270,000
Total Capital Costs				$270,000
Sitework	5%			$14,000
Electrical and Instrumentation	12%			$32,000
HVAC & Plumbing	5%			$14,000
Contingencies	30%			$80,000
Contruction Subtotal				$410,000
CM Services, General Conditions	15%			$62,000
Engineering, Legal & Administration	15%			$62,000
Total Project Cost				**$530,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$14,000	$14,000
Labor				
Operations	1	LS	$0	$0
Maintenance	1	LS	$6,000	$6,000
Media Replacement	1	LS	$0	$0
Yearly Cost for Maintenance Equipment	1	1%	$2,050	$2,000
Subtotal - Gas Cleaning				***$22,000***
Natural Gas Credit				($74,000)
Total Operating Cost				**($52,000)**

PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$530,000
Total PW Capital Costs (Includes SV)	$530,000
Present Worth Cost of Annual O&M	**($648,000)**
Total Present Worth Costs	**($118,000)**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	($9,000)
Annual Average Gas Production (scf/yr)	37,706,000
Annualized Unit Cost ($/scf)	***$0.000***

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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Title:	**Cost Summary of Digester Gas Utilization**	Date:	January 0, 1900
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Case 2: Engine Generators

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	15	cy	$700	$11,000
Canopy	400	sqft	$35	$14,000
Gas Cleaning Equipment Package[1]	1	LS	$323,200	$323,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$98,000	$98,000
Subtotal - Gas Cleaning				***$450,000***
Cogeneration Facility				
Total Power Generation	265	kWh/hr		
Canopy	500	sqft	$35	$18,000
Overhead Crane	1	ea	$5,000	$5,000
Engine Gen and Heat Recovery System	2	ea	$107,000	$214,000
Engine Generator Enclosure	2	ea	$24,000	$48,000
Booster compressor package		Included with Gas Cleaning System		
Equipment Installation	1	20%	$53,000	$53,000
Subtotal - Cogeneration Facility				***$340,000***
Subtotal				**$790,000**

Total Capital Costs		$790,000
Sitework	5%	$40,000
Electrical and Instrumentation	12%	$95,000
HVAC & Plumbing	5%	$40,000
Contingencies	30%	$240,000
Contruction Subtotal		$1,210,000
CM Services, General Conditions	15%	$182,000
Engineering, Legal & Administration	15%	$182,000
Total Project Cost		**$1,570,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$16,000	$16,000
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$7,000	$7,000
Media Replacement	1	LS	$33,000	$33,000
Yearly Cost for Maintenance Equipment	1	1%	$3,280	$3,000
Subtotal - Gas Cleaning				***$75,000***
Congeneration Facility				
Power	1	LS	$0	--
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$9,000	$9,000
Yearly Cost for Maintenance Equipment		$/kW	$0.015	$35,000
Subtotal - Cogeneration				***$60,000***
Natural Gas Credit				($74,000)
Total Operating Cost				**$61,000**
Credit for Power Produced		$/kW	$0.086	($200,000)

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$1,570,000
Total PW Capital Costs (Includes SV)	$1,570,000
Present Worth Cost of Annual O&M	**$760,000**
Present Worth Cost of Generated Power	**($2,492,000)**
Total Present Worth Costs	**($162,000)**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	($13,000)
Annual Average Gas Production (scf/yr)	37,706,000
Annualized Unit Cost ($/scf)	***($0.000)***
Annual Average Electricity Production (kW-h/yr)	2,321,000
Annualized Unit Cost ($/kWh)	***$0.081***

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Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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Case 3: Microturbines

CAPITAL COST

Item Description	No. of Units		Unit Cost	2010 Cost
Digester Gas Cleaning System				
Concrete Pad	15	cy	$700	$11,000
Canopy	400	sqft	$35	$14,000
Gas Cleaning Equipment Package[1]	1	LS	$381,000	$381,000
Hoist and Steel Frame	1	LS	$5,000	$5,000
Equipment Installation	1	30%	$116,000	$116,000
Subtotal - Gas Cleaning				***$530,000***
Cogeneration Facility				
Total Power Generation	197	kWh/hr		
Canopy	400	sqft	$35	$14,000
Overhead Crane	1	ea	$5,000	$5,000
Microturbine and Heat Recovery System	3	*ea*	$107,200	$322,000
Booster compressor package		Included with Gas Cleaning System		
Equipment Installation	1	20%	$65,000	$65,000
Subtotal - Cogeneration Facility				***$410,000***
Subtotal				**$940,000**

Total Capital Costs		$940,000
Sitework	5%	$47,000
Electrical and Instrumentation	12%	$113,000
HVAC & Plumbing	5%	$47,000
Contingencies	30%	$280,000
Contruction Subtotal		$1,430,000
CM Services, General Conditions	15%	$215,000
Engineering, Legal & Administration	15%	$215,000
Total Project Cost		**$1,860,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Digester Gas Cleaning				
Power	1	LS	$28,000	$28,000
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$7,000	$7,000
Media Replacement	1	LS	$33,000	$33,000
Yearly Cost for Maintenance Equipment	1	1%	$3,860	$4,000
Subtotal - Gas Cleaning				***$88,000***
Congeneration Facility				
Power	1	LS	$0	--
Labor				
Operations	1	LS	$16,000	$16,000
Maintenance	1	LS	$4,000	$4,000
Yearly Cost for Maintenance Equipment		$/kW	$0.008	$14,000
Subtotal - Cogeneration				***$34,000***
Natural Gas Credit				($71,000)
Total Operating Cost				**$51,000**
Credit for Power Produced		$/kW	$0.086	($148,000)

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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D O N O T W R I T E I N T H I S S P A C E

PRESENT WORTH COSTS

Parameter	$/year
Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.38)
Year 0 Capital Costs	$1,860,000
Total PW Capital Costs (Includes SV)	$1,860,000
Present Worth Cost of Annual O&M	$636,000
Present Worth Cost of Generated Power	**($1,844,000)**
Total Present Worth Costs	**$652,000**

ANNUALIZED COSTS

Parameter	$/year
Annualized Present Worth Costs	$52,000
Annual Average Gas Production (scf/yr)	37,706,000
Annualized Unit Cost ($/scf)	***$0.001***
Annual Average Electricity Production (kW-h/yr)	1,724,000
Annualized Unit Cost ($/kWh)	***$0.116***

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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POWER USE AND COST

Unit Cost for Power (per kWh) $0.086

Case 1: Boilers

Centralized Facility								
Equipment List	**No. of Units**	**Installed HP**	**Operating HP**	**Hr/Day**	**Day/Wk**	**Wk/Yr**	**kWh/Yr**	**Cost $/yr**
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	3	2.4	24	7	52	19,551	$1,681
Chilling Unit	1	15	12.0	24	7	52	97,756	$8,407
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**162,926**	**$14,000**

Case 2: Engine Generators

Centralized Facility								
Equipment List	**No. of Units**	**Installed HP**	**Operating HP**	**Hr/Day**	**Day/Wk**	**Wk/Yr**	**kWh/Yr**	**Cost $/yr**
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	4	3.2	24	7	52	26,068	$2,242
Chilling Unit	1	18	14.4	24	7	52	117,307	$10,088
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**188,995**	**$16,000**

Case 3: Microturbines

Centralized Facility								
Equipment List	**No. of Units**	**Installed HP**	**Operating HP**	**Hr/Day**	**Day/Wk**	**Wk/Yr**	**kWh/Yr**	**Cost $/yr**
Gas Cleaning								
Recirculation Pump	1	2	1.6	24	7	52	13,034	$1,121
Compressor	1	25	20.0	24	7	52	162,926	$14,012
Chilling Unit	1	18	14.4	24	7	52	117,307	$10,088
Miscellaneous	1	5	4.0	24	7	52	32,585	$2,802
Total							**325,853**	**$28,000**

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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LABOR REQUIREMENT AND COSTS

Operation Labor	$30.0
Maintenaince Labor	$32.5

Case 1: Boilers

Centralized Facility								
Labor Category	Number	Hr/Shift	Shift/Day	Day/Wk	Wk/Yr	Total Hours	Hourly Rate	Cost, $/yr
Gas Cleaning								
Operation	0	0.5	3.0	7	52	0	$30.0	0
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	0	8	1.0	4	1	0	$32.5	0
Subtotal						**182**		**$6,000**

Case 2: Engine Generators

Centralized Facility								
Labor Category	Number	Hr/Shift	Shift/Day	Day/Wk	Wk/Yr	Total Hours	Hourly Rate	Cost, $/yr
Gas Cleaning								
Operation	1	0.5	3.0	7	52	546	$30.0	16,000
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	1	8	1.0	4	1	32	$32.5	1,000
Subtotal						**760**		**$23,000**
Engine Generators								
Operation	1	0.5	3.0	7	52	546	$30.0	16,380
Maintenance (general)	2	0.3	1.0	7	52	218	$32.5	7,098
Maintenance (other)	2	8	1.0	4	1	64	$32.5	2,080
Subtotal						**828**		**$26,000**

Case 3: Microturbines

Maintenance (general)								
Labor Category	Number	Hr/Shift	Shift/Day	Day/Wk	Wk/Yr	Total Hours	Hourly Rate	Cost, $/yr
Gas Cleaning								
Operation	1	0.5	3.0	7	52	546	$30.0	16,000
Maintenance (general)	1	0.5	1.0	7	52	182	$32.5	6,000
Maintenance (media replace	1	8	1.0	4	1	32	$32.5	1,000
Subtotal						**760**		**$23,000**
Microturbines								
Operation	1	0.5	3.0	7	52	546	$30.0	16,380
Maintenance (general)	1	0.15	1.5	7	52	82	$32.5	2,662
Maintenance (other)	1	8	1.5	4	1	48	$32.5	1,560
Subtotal						**676**		**$21,000**

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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NATURAL GAS CREDITS

Natural Gas Cost ($/mmBtu) $10.60

Case 1: Boilers

Centralized Facility								
Month	**Day/Month**	**Digester Heat Rqrmt**	**Heat Available**	**Nature Gas**	**Credits**		**Unit Price ($/mmBtu)**	**Cost ($/yr)**
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	1.05	2.06	0.00	1.05	778.8		
February	28	1.04	2.06	0.00	1.04	695.7		
March	31	0.83	2.06	0.00	0.83	618.9		
April	30	0.80	2.06	0.00	0.80	574.2		
May	31	0.77	2.06	0.00	0.77	569.8		
June	30	0.55	2.06	0.00	0.55	395.6		
July	31	0.55	2.06	0.00	0.55	407.0		
August	31	0.55	2.06	0.00	0.55	407.0		
September	30	0.75	2.06	0.00	0.75	537.6		
October	31	0.78	2.06	0.00	0.78	579.4		
November	30	0.86	2.06	0.00	0.86	622.1		
December	31	1.05	2.06	0	1.05	778.8		
Total				**mmBtu/yr**		**6,965**	**$ 10.60**	**($74,000)**

Case 2: Engine Generators

June								
Month	**Day/Month**	**Digester Heat Rqrmt**	**Heat Available**	**Nature Gas**	**Credits**		**Unit Price ($/mmBtu)**	**Cost ($/yr)**
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	1.05	1.16	0.00	1.05	778.8		
February	28	1.04	1.16	0.00	1.04	695.7		
March	31	0.83	1.16	0.00	0.83	618.9		
April	30	0.80	1.16	0.00	0.80	574.2		
May	31	0.77	1.16	0.00	0.77	569.8		
June	30	0.55	1.16	0.00	0.55	395.6		
July	31	0.55	1.16	0.00	0.55	407.0		
August	31	0.55	1.16	0.00	0.55	407.0		
September	30	0.75	1.16	0.00	0.75	537.6		
October	31	0.78	1.16	0.00	0.78	579.4		
November	30	0.86	1.16	0.00	0.86	622.1		
December	31	1.05	1.16	0.00	1.05	778.8		
Total				**mmBtu/yr**		**6,965**	**$ 10.60**	**($74,000)**

Owner:	City of Prescott	Computed By:	YQ
Plant:	Centralized Facility	Date:	June 4, 2010
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Case 3: Microturbines

September								
Month	**Day/Month**	**Digester Heat Rqrmt**	**Heat Available**	**Nature Gas**	**Credits**		**Unit Price ($/mmBtu)**	**Cost ($/yr)**
		mmBtu/hr	mmBtu/hr	mmBtu/hr	mmBut/hr	mmBtu/mo		
January	31	1.05	0.93	0.12	0.93	691.0		
February	28	1.04	0.93	0.11	0.93	624.2		
March	31	0.83	0.93	0.00	0.83	618.9		
April	30	0.80	0.93	0.00	0.80	574.2		
May	31	0.77	0.93	0.00	0.77	569.8		
June	30	0.55	0.93	0.00	0.55	395.6		
July	31	0.55	0.93	0.00	0.55	407.0		
August	31	0.55	0.93	0.00	0.55	407.0		
September	30	0.75	0.93	0.00	0.75	537.6		
October	31	0.78	0.93	0.00	0.78	579.4		
November	30	0.86	0.93	0.00	0.86	622.1		
December	31	1.05	0.93	0.12	0.93	691.0		
Total				**mmBtu/yr**		**6,718**	**$ 10.60**	**($71,000)**