Prepared for

Truckee Meadows Water Reclamation Facility
City of Reno and City of Sparks, Nevada

Financial Grade Operational Audit

Agreement No. 112-013

January 10, 2014

AMERESCO
Green • Clean • Sustainable

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Nevada

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Executive Summary

Ameresco, Inc. (Ameresco) is pleased to present this Financial-Grade Operational Audit (FGOA) report to the Truckee Meadows Water Reclamation Facility (TMWRF) pursuant to the Financial Grade Audit Agreement No. 112-013 entered into by Ameresco, City of Reno, and City of Sparks on August 22, 2012. The audit includes all buildings and treatment process systems at the plant. Special thanks to Michael Drinkwater, Robert Lee, Kim Laber, Todd Saxberg, Dave Brant, Jason Geddes, and other TMWRF personnel who helped us perform this audit.

Based on the data collected from site surveys, facility interviews, data logging, and other means, Ameresco identified and recommends seven Energy Conservation Measures (ECMs) that will help TMWRF reduce overall operation costs and address long term plant operation needs. A summary of the ECMs included in the project is listed in Table ES.1.

Table ES.1 Summary of ECMs Included in Project

ECMs	Scope Summary
ECM 2: Centrate Nutrient Recovery	Install a side stream treatment process to extract nutrients and transforms them into fertilizer.
ECM 4A: Biogas Cogeneration System	Install an 850-kW cogeneration system with digester gas fuel to generate electricity and heat.
ECM 4B: Digester Domes Rehabilitation	Rehabilitate digester domes #1 and #3 to stop gas leaks.
ECM 6: Dewatering System Upgrade	Replace 2 centrifuges and 2 cake pumps with new high efficiency equipment.
ECM 7: Lighting System Upgrade	Retrofit 1,597 light fixtures with high efficiency lamps, ballasts, and controls.
ECM 9: Near Term Dewatering Improvement	Replace the polymer system at dewatering facility, and rehabilitate the dewatering building.
ECM 10: MyEnergyPro™	Install a web-based software tool for tracking and optimizing utility use at the plant.

Total annual savings from implementing the ECMs is $1,122,887. The annual savings is a combination of savings in electricity, chemicals, and biosolids removal, as well as new revenue streams for TMWRF after implementing the ECMs. ***The total project investment of $25,036,589*** includes Ameresco's audit fee, payment and performance bonds, and third party consultant fees, whose services are required by Nevada Statute.

The payment bond serves as an assurance to the Owner that the Contractor has paid all subcontractors and material suppliers that provided services or materials for the project in full. The performance bond guarantees the physical completion of the project and a one-year warranty for the installed work.

Performance and payment bonds only apply to the installation portion of the contract and do not apply to energy savings guarantees, payment of potential savings shortfalls, or maintenance provisions.

Ameresco guarantees the savings by providing measurement and verification (M&V) services at the end of construction and annually throughout the subsequent 15 year performance period. M&V services will be supported by Ameresco's MyEnergyPro™ software, which Ameresco will maintain to track energy and chemical consumption (included in the project scope and services).

The cash flow contains budget allocations for operations and maintenance (O&M) tasks required by new systems which require ongoing services that exceed TMWRF's existing O&M activities. It does not reflect additional O&M services provided by Ameresco. TMWRF will operate and maintain the systems after installation using internal staff, third party contractors, or a combination thereof.

The project proforma is provided following this Executive Summary. The proforma is generated based on TMWRF funding the project internally without third party financing. Cost for third party engineering review of the audit is included in the proforma; however, is not part of the total construction costs paid to Ameresco. TMWRF will select the consultant and directly reimburse for services provided. The proforma uses escalation rates for the various utilities (e.g., electricity) to account for projected rate increases through the 15 year performance period.

Implementing the ECMs recommended in the project will provide the following benefits to TMWRF:

- Reduce electricity consumption by 5,817,735 kilowatt hours (kWh) and $350,049 per year.
- Reduce methanol consumption by 29,895 gallons and $53,273 per year.
- Reduce alum consumption by 1,155 dry tons and $444,817 per year.
- Decrease TMWRF's total biosolids hauling and disposal costs by $233,101 per year.
- Installing the Ostara side stream treatment process will produce commercial-grade fertilizer that will generate $140,424 in annual revenue for TMWRF.

In addition to the above monetary benefits, the project will also help TMWRF address outstanding operational issues and position TMWRF for future growth.

- The side stream treatment will increase stability of the treatment process and will provide TMWRF with a better nutrient removal system so TMWRF can more readily meet discharge permit requirements.
- Installing the biogas cogeneration system will help TMWRF address EPA's environmental concerns from flaring the digester gas.
- Rehabilitating the digester domes will stop gas leaks from the digesters and prevent damaging corrosion at the nearby main electrical switchgear.

- The project will upgrade and rehabilitate TMWRF's dewatering system which is at the end of its life cycle.
- Electricity savings and on site generation from the project will help TMWRF take a significant step towards the long-term net zero energy goal for the plant.

There are environmental benefits from implementing the project as well. In terms of pollution reduction, energy savings from the project will provide the following:

- Avoid the production of 4,820 tons of Carbon Dioxide, 5,562 pounds of Sulfur Dioxide, and 8,860 pounds of Nitric Oxide per year.
- This reduction in Carbon Dioxide is equivalent to removing 814 cars from the road, or powering 582 homes per year.

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Project Proforma
Truckee Meadows Water Reclamation Facility (January 10, 2014)

Initial Project Costs:		
Detailed Energy Audit	$	149,835
Performance and Payment Bond, Permits	$	210,930
Implementation Costs	$	24,550,824
Total Initial Project Costs	**$**	**24,911,589**
3rd Party Consultant Fee	**$**	**125,000**
Net Project Costs	**$**	**25,036,589**
Customer Contribution	**$**	**(25,036,589)**
Total Amount Financed	**$**	**-**

Financial Assumptions	
Term of Project (years)	15.0 yrs
Term of Financing (years)	15.0 yrs
Estimated Financing Rate	0.00%
Payments per Year (frequency)	-
Discount Rate	3.75%
Electricity Escalation Rate (annual)	2.89%
Chemical Cost Escalation Rate (annual)	2.89%
Biosolid Hauling Escalation Rate (annual)	3.19%
Biosolid Disposal Escalation Rate (annual)	2.38%
Fertilizer Sale Escalation Rate (annual)	0.00%
M&V and O&M Cost Escalation Rate (annual)	2.38%

Proforma — *Year*

	Initial Values	1	2	3	4	5	6	7	8	9	10
1 Electricity Cost Savings	$ 350,049	$ 360,165	$ 370,574	$ 381,284	$ 392,303	$ 403,641	$ 415,306	$ 427,308	$ 439,657	$ 452,363	$ 465,437
2 Chemical Cost Savings	$ 498,090	$ 512,485	$ 527,296	$ 542,534	$ 558,214	$ 574,346	$ 590,945	$ 608,023	$ 625,595	$ 643,675	$ 662,277
3 Biosolid Hauling Cost Savings	$ 63,237	$ 65,254	$ 67,336	$ 69,484	$ 71,700	$ 73,988	$ 76,348	$ 78,783	$ 81,297	$ 83,890	$ 86,566
4 Biosolid Disposal Cost Savings	$ 169,864	$ 173,907	$ 178,046	$ 182,283	$ 186,622	$ 191,063	$ 195,610	$ 200,266	$ 205,032	$ 209,912	$ 214,908
5 Fertilizer Sale Savings	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424
6 Total Cost Savings (Sum of Lines 1 to 5)	$ 1,221,664	$ 1,252,235	$ 1,283,675	$ 1,316,009	$ 1,349,263	$ 1,383,461	$ 1,418,633	$ 1,454,804	$ 1,492,005	$ 1,530,264	$ 1,569,611
7 Guaranteed Cost Savings	**$ 1,099,498**	**$ 1,127,012**	**$ 1,155,308**	**$ 1,184,408**	**$ 1,214,336**	**$ 1,245,115**	**$ 1,276,769**	**$ 1,309,324**	**$ 1,342,804**	**$ 1,377,238**	**$ 1,412,650**
8 Total O&M Savings	$ (98,777)	$ (101,128)	$ (103,535)	$ (105,999)	$ (108,522)	$ (111,104)	$ (113,749)	$ (116,456)	$ (119,228)	$ (122,065)	$ (124,970)
9 Stipulated Savings	$ 96,439	$ 99,111	$ 101,857	$ 104,680	$ 107,580	$ 110,561	$ 113,624	$ 116,772	$ 120,008	$ 123,333	$ 126,750
10 NV Energy Rebates (Note 4)		$ 15,995									
11 Renewable Energy Credits ($0.005/kWh)	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481
12 Total Project Savings (Sum of Lines 7 to 11)	**$ 1,125,641**	**$ 1,169,471**	**$ 1,182,112**	**$ 1,211,570**	**$ 1,241,875**	**$ 1,273,052**	**$ 1,305,125**	**$ 1,338,121**	**$ 1,372,065**	**$ 1,406,986**	**$ 1,442,910**
13 TMWRF Future Years CIP Contribution											
14 Total Project Funds Available (Line 12 + Line 13)	**$ 1,125,641**	**$ 1,169,471**	**$ 1,182,112**	**$ 1,211,570**	**$ 1,241,875**	**$ 1,273,052**	**$ 1,305,125**	**$ 1,338,121**	**$ 1,372,065**	**$ 1,406,986**	**$ 1,442,910**
15 Payments for Financing Equipment		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
16 Payments from CIP Contribution											
17 Payments for Measurement and Verification Services	$ 38,665	$ 39,585	$ 40,527	$ 41,492	$ 42,480	$ 43,491	$ 44,526	$ 45,586	$ 46,671	$ 47,782	$ 48,919
18 Payments for My Energy Pro Services	$ 9,375	$ 9,598	$ 9,827	$ 10,060	$ 10,300	$ 10,545	$ 10,796	$ 11,053	$ 11,316	$ 11,585	$ 11,861
19 Total Payments (Sum of Lines 15 to 18)	**$ 48,040**	**$ 49,183**	**$ 50,354**	**$ 51,552**	**$ 52,780**	**$ 54,036**	**$ 55,322**	**$ 56,639**	**$ 57,987**	**$ 59,367**	**$ 60,780**
20 Net Annual Benefit (Line 14 - Line 19)		**$ 1,120,288**	**$ 1,131,758**	**$ 1,160,017**	**$ 1,189,095**	**$ 1,219,016**	**$ 1,249,803**	**$ 1,281,482**	**$ 1,314,078**	**$ 1,347,619**	**$ 1,382,130**
21 Cumulative Cash Flow	**$ 19,859,644**	$ 1,120,288	$ 2,252,046	$ 3,412,063	$ 4,601,159	$ 5,820,175	$ 7,069,978	$ 8,351,460	$ 9,665,538	$ 11,013,157	$ 12,395,288
22 Net Present Value of Cash Flow	**$ 14,728,565**										

Line #	11	12	13	14	15	Totals
1 Electricity Cost Savings	$ 478,888	$ 492,728	$ 506,967	$ 521,619	$ 536,694	$ 6,644,933
2 Chemical Cost Savings	$ 681,417	$ 701,109	$ 721,372	$ 742,219	$ 763,669	$ 9,455,174
3 Biosolid Hauling Cost Savings	$ 89,327	$ 92,177	$ 95,117	$ 98,152	$ 101,283	$ 1,230,702
4 Biosolid Disposal Cost Savings	$ 220,023	$ 225,259	$ 230,621	$ 236,109	$ 241,729	$ 3,091,390
5 Fertilizer Sale Savings	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 2,106,360
6 Total Cost Savings (Sum of Lines 1 to 5)	$ 1,610,079	$ 1,651,697	$ 1,694,501	$ 1,738,523	$ 1,783,798	$ 22,528,560
7 Guaranteed Cost Savings	**$ 1,449,071**	**$ 1,486,528**	**$ 1,525,051**	**$ 1,564,671**	**$ 1,605,419**	**$ 20,275,704**
8 Total O&M Savings	$ (127,945)	$ (130,990)	$ (134,107)	$ (137,299)	$ (140,567)	$ (1,797,663)
9 Stipulated Savings	$ 130,262	$ 133,871	$ 137,580	$ 141,392	$ 145,310	$ 1,812,690
10 NV Energy Rebates (Note 4)						$ 15,995
11 Renewable Energy Credits ($0.005/kWh)	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 427,214
12 Total Project Savings (Sum of Lines 7 to 11)	**$ 1,479,869**	**$ 1,517,890**	**$ 1,557,005**	**$ 1,597,245**	**$ 1,638,643**	**$ 20,733,940**
13 TMWRF Future Years CIP Contribution						$ -
14 Total Project Funds Available (Line 12 + Line 13)	**$ 1,479,869**	**$ 1,517,890**	**$ 1,557,005**	**$ 1,597,245**	**$ 1,638,643**	**$ 20,733,940**
15 Payments for Financing Equipment	$ -	$ -	$ -	$ -	$ -	$ -
16 Payments from CIP Contribution						$ -
17 Payments for Measurement and Verification Services	$ 50,083	$ 51,275	$ 52,495	$ 53,744	$ 55,023	$ 703,679
18 Payments for My Energy Pro Services	$ 12,143	$ 12,432	$ 12,728	$ 13,031	$ 13,341	$ 170,618
19 Total Payments (Sum of Lines 15 to 18)	**$ 62,226**	**$ 63,707**	**$ 65,223**	**$ 66,775**	**$ 68,364**	**$ 874,297**
20 Net Annual Benefit (Line 14 - Line 19)	**$ 1,417,643**	**$ 1,454,183**	**$ 1,491,782**	**$ 1,530,470**	**$ 1,570,279**	**$ 19,859,644**
21 Cumulative Cash Flow	$ 13,812,931	$ 15,267,113	$ 16,758,895	$ 18,289,365	$ 19,859,644	

Notes:

1 This cash flow reflects an estimated tax exempt lease rate of 0%. The actual rate will increase or decrease based on market conditions and customer credit rating at the time of lease funding.
2 Revenues are based on current utility rate structures and usage information provided for purposes of this project.
3 The performance and payment bonds apply only to the installation portion of the contract and do not apply in any way to energy savings guarantees, payments or maintenance provisions, except that the performance bond shall guarantee that the installation will be free of defective materials and workmanship for a period of 12 months following completion and acceptance of the work
4 The amount of the utility rebate(s) are not guaranteed. The final rebate amount will be determined by the utility company.
5 Electricity escalation rate is calculated based on NIST Energy Price Indices for commercial electricity for census region 4. A copy of the table is included in the FGOA Appendix.
6 Chemical cost escalation rate is assumed the same as electricity escalation rate.
7 Biosolids hauling cost escalation rate is based on transportation fuel price escalation. It is calculated using U.S. EIA Independent Statistics and Analysis data for 2014 to 2030.
8 Biosolids disposal cost escalation rate is based on Nevada CPI increases from 2002 to 2012. Data is from U.S. Dept of Labor - Bureau of Labor and Statistics.
9 O&M and M&V costs escalation rates are based on Nevada CPI increases from 2002 to 2012. Data is from U.S. Dept of Labor - Bureau of Labor and Statistics.

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Table of Contents

List of Tables

List of Figures

Acronyms

Please reference Table A.1 for a list of acronyms used throughout this document.

Table A.1. Acronym List

Acronym	Definition
A/C	air conditioning
AFD	adjustable frequency drive
AHU	air handling unit
AIC	ampere interrupting capacity
Ameresco	Ameresco, Inc.
AP	acid phase
APD	acid phase digester
ARAS	anaerobic return activated sludge
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
Btu	British thermal units
CF	cubic foot
CFL	compact fluorescent lamps
CFM	cubic feet per minute
CIP	Capital Improvement Plan
CO_2	carbon dioxide
CPI	Consumer Price Index
CPI-U	Consumer Price Index for urban consumers
DAFT	dissolved air floatation thickening
DCS	distributed control system
DO	dissolved oxygen
DX	direct expansion
ECI	energy cost index
ECM	energy conservation measure
EIA	U.S. Energy Information Administration
FCU	fan coil unit
FT	foot
FTE	full time employee
FY	fiscal year
GPM	gallons per minute
GT	gravity thickener
HID	high-intensity discharge
HO	high output
HP	horsepower
HPS	high pressure sodium
HVAC	heating, ventilating, and air conditioning
Hz	hertz
IES	Illuminating Engineering Society
IPMVP	International Performance Measurement and Verification Protocol
ISS	inert suspended solid
K	kelvin

Table A.1. Acronym List

Acronym	Definition
kW	kilowatt
kWh	kilowatt hour
LED	light emitting diode
LVDC	low voltage distribution center
MCC	motor control center
mg	milligram
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MBH	million British thermal units per hour
MMBtu	million British thermal units (Btu)
MPD	methane phase digester
n/a	not applicable
NIST	National Institute for Standards and Testing
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
oph	operation hour
PE	Professional Engineer
PLC	programmable logic controller
PRS	phosphor removal system
PUCN	Public Utility Commission of Nevada
PUF	polyurethane foam
PV	photovoltaic
RAS	return activated sludge
REC	Renewable Energy Credit
RTU	rooftop unit
SCADA	supervisory control and data acquisition
SCFH	standard cubic feet per hour
SF	square foot
Therms	natural gas consumption unit
TOU	time of use
TIMS	TMWRF information management system
TPS	thickened primary sludge
TWAS	thickened waste-activated sludge
V	volt
VAV	variable air volume
VFD	variable frequency drive
VSD	variable speed drive
WAM	wide-area network
WAS	waste-activated sludge

1.0 Project Overview

Pursuant to the Financial Grade Audit Agreement No. 112-013 entered into by Ameresco, City of Reno, and City of Sparks on August 22, 2012, Ameresco performed an energy audit at the Truckee Meadows Water Reclamation Facility (TMWRF) located at 8500 Clean Water Way, Reno NV, 89502. The audit, and the project development works that followed, were conducted from September 2012 to July 2013. This report is a compilation of all of the surveys, data collections, engineering analyses, and recommendations that resulted from this audit.

Organization of this report is as follows: Section 2 provides a description of the buildings and treatment process at the plant from our technical surveys. Detailed descriptions of energy and utility consumption at the plant are included in Section 3. Section 4 provides the description of the energy conservation measures (ECMs) in the project, including scopes of the ECM and savings calculations. More detailed engineering analyses, calculations, and preliminary drawings for the ECMs, as well as equipment cut sheets are included as appendices. Section 5 describes the project financials. Sections 6, 7, and 8 provide descriptions for the post-construction activities for the project. Section 6 covers the Measurement and Verification (M&V) phase of the project, while Section 7 covers the Commissioning phase. Section 8 describes the Operations and Maintenance (O&M) requirements during the performance period to maintain cost savings.

1.1 Financial Grade Operational Audit Overview

The audit and development process consisted of three phases:

1. **Baseline utility analysis**

   In this phase of the audit, Ameresco performed a comprehensive study of energy and utility consumption at the plant. We collected and analyzed invoices for electricity, water, propane, chemicals, biosolids disposal, and all other utilities. We collected consumption data from existing meters either through the plant's SCADA system or through the utility companies. To capture the variability and annual trend, the analysis was done using 36 months of utility data. All of the information allowed Ameresco to create a baseline utility use at the plant and to start developing strategies to reduce them.

2. **Technical analysis and engineering development**

   Using the utility baseline, Ameresco then performed technical surveys and engineering analyses of the wastewater treatment process and its supporting systems. We conducted technical analyses of the process and used the results to develop ECMs. We performed engineering analysis of the ECMs to determine their feasibility and savings potential. Development of the ECMs was performed interactively in conjunction with TMWRF personnel and incorporated their inputs. The ECMs were systematically refined during this audit phase to result in the final scope of the project.

3. **Financial development**

   After Ameresco and TMWRF determined the final project scope, we performed financial analyses to determine the project costs and annual cash flow. We conducted value engineering to ensure the project delivers best value to TMWRF. We also investigated the applicability of utility rebates and other incentives that will help reduce project costs. Results of the financial analysis are then delivered to TMWRF along with the detail project scope as a complete package of energy and cost savings project.

1.2 Utility Baseline Overview

Table 1.1 shows a summary of the baseline utility consumption and cost at TMWRF. A detailed breakdown of the utility analysis is presented in Section 3. Total baseline utility cost for TMWRF is over $7.6 million per year. This cost includes the costs for electricity, propane, water, chemicals, and waste disposal. Chemical cost is the largest utility cost at the plant and accounts for 56% of the total cost. Methanol and polymer are the two largest contributors to the chemical cost. Electricity cost is $2.5 million per year, and accounts for 33% of the total cost. Waste disposal cost is $787,808 per year, which includes the cost for hauling and disposing of the dewatered biosolids. This cost accounts for 10% of the total utility cost. Propane and water use at the plant are very small components of the plant's utility cost.

Table 1.1. Summary of Utility Baseline

Utility	Baseline consumption (per year)	Unit	Baseline cost (per year)
Electricity	30,820,590	kWh	$2,503,863
Propane	n/a	Gallons	$38,442
Water & Sewer	n/a	kGallons	$1,788
Chemicals			
Aluminum Sulfate	1,439	Ton	$482,976
Polymer	995,317	Pounds	$1,003,691
Ferric Chloride	116	Ton	$85,740
Methanol	1,043,735	Gallons	$1,994,464
Sodium Bisulfate	239	Ton	$180,989
Sodium Hydroxide	33	Ton	$19,432
Sodium Hypochlorite	709,326	Gallons	$496,801
Other Chemicals			$65,282
Subtotal Chemicals			**$4,329,375**
Waste Disposal			
General Waste	n/a	n/a	$30,220

Table 1.1. Summary of Utility Baseline

Utility	Baseline consumption (per year)	Unit	Baseline cost (per year)
Biosolids Hauling	2,126	Trips	$208,635
Biosolids Landfill Disposal	46,435	Ton	$548,953
Subtotal Waste Disposal			**$787,808**
		TOTAL	***$7,661,276***

1.3 Technical Overview

Based on the data collected from site surveys, facility interviews, data logging, and other means, Ameresco identified and recommends seven Energy Conservation Measures (ECMs) that will help TMWRF reduce overall operation costs and address long term plant operation needs. A summary of the ECMs included in the project is listed in Table 1.2. A brief description of each ECM is provided following the table. Detail descriptions of the ECMs are provided in Section 4.

Table 1.2. Summary of ECMs Included in the Project

ECMs	Scope summary
ECM 2: Centrate Nutrient Recovery	Install a side stream treatment process to extract nutrients and transforms them into fertilizer.
ECM 4A: Biogas Cogeneration System	Install a 850-kW cogeneration system with digester gas fuel to generate electricity and heat.
ECM 4B: Digester Domes Rehabilitation	Rehabilitate digester domes #1 and #3 to stop gas leaks.
ECM 6: Dewatering System Upgrade	Replace two centrifuges and two cake pumps with new high efficiency equipment.
ECM 7: Lighting System Upgrade	Retrofit 1,597 light fixtures with high efficiency lamps, ballasts, and controls.
ECM 9: Near Term Dewatering Improvement	Replace the polymer system at dewatering facility, and rehabilitate the dewatering building.
ECM 10: MyEnergyPro™	Install a web-based software tool for tracking and optimizing utility use at the plant.

1.3.1 Measures Included in the Project

> ECM 2: Centrate Nutrient Recovery

Recycling steam from solids handling (centrate) introduces additional nitrogen and phosphorous loads into the wastewater treatment process. This ECM proposes to remove the additional phosphorous load through a struvite precipitation process. Phosphate removal through struvite precipitation has gained popularity in recent years due to its importance as a sustainable practice, application in managing facility nutrient recycle loads, and pipe scaling management. Currently, TMWRF removes phosphate from the centrate by chemical means with the addition of aluminum sulfate (alum). Implementing this ECM will eliminate the chemical cost of the existing phosphorous removal system, as well as generate an income stream for TMWRF by selling the fertilizer produced during the process.

> ECM 4A: Biogas Cogeneration System

This ECM proposes the implementation of a new cogeneration (cogen) system that uses biogas produced in the anaerobic digesters to generate power. Waste heat would also be recovered from the system for multiple uses in the plant. The existing cogen system is no longer in service due to operation and maintenance issues, in addition to limitations on the quality and quantity of digester gas produced. As part of this ECM, the existing system will be upgraded with a new and more efficient engine. The system will utilize the new digester gas cleaning system currently under construction in a separate project.

> ECM 4B: Digester Domes Rehabilitation

Ameresco recommends repairing the cover of digester 3 as recommended in Brown and Caldwell's study commissioned by TMWRF prior to this energy audit. Repairing this cover will improve plant safety by eliminating digester gas leakage and prevent corrosion at the nearby main electrical switchgear. Repairing the cover will also improve sludge digestion performance and increase the amount of digester gas produced, which will increase the electricity output from the cogeneration engine installed under the scope of ECM 4A. Ameresco also recommends repairing the cover for digester 1 in addition to digester 3 to ensure there is no gas leakage from digester 1.

> ECM 6: Dewatering System Upgrade

Ameresco recommends upgrading the Solids Dewatering Facility at TMWRF. The existing centrifuges will be demolished and replaced with new, more efficient centrifuges. Existing dewatered cake piston pumps require extensive maintenance and will be replaced with new cake pumps. Existing cake pump discharge pipes cannot handle the required cake discharge pressures to pump drier cake, so they will be replaced. The existing liquid polymer system for sludge dewatering is manual and will be replaced with a new automated system. Cost savings for this upgrade is primarily due to a higher cake solid content, which reduces the amount of biosolids generated. This, in turn, will reduce the cost of hauling and disposing of the biosolids in the landfill. Additional cost savings will also be realized from reduced equipment power usage.

> ECM 7: Lighting System Upgrade

Ameresco recommends retrofitting existing light fixtures with newer and more efficient lighting technology. Installing lighting controls wherever applicable is also recommended. Retrofitting these existing fixtures and lamps with more efficient alternatives and installing automated controls will reduce peak demand and electricity consumption at TMWRF.

> ECM 9: Near Term Dewatering Improvement

Prior to this project, TMWRF had contracted CH2MHILL to identify several near-term improvements needed at the Solids Dewatering Facility. A major part of the improvements involved the upgrade to the existing polymer system at the facility, but the recommendations also include critical items to be addressed immediately, such as upgrades to the electrical and ventilation systems.

Ameresco recommends that TMWRF include the near-term dewatering improvement project into the overall ESCO project because there is overlap between Ameresco's proposal for the facility (ECM 6) and this ECM. TMWRF will benefit from having one point of accountability for the upgrades in the facility, and eliminate the potential for miscommunication between separate contractors. Furthermore, the overall construction cost will be lower by eliminating duplicate mobilization cost, overhead costs, etc. The construction period will be shorter due to a more streamlined coordination of the field work.

> ECM 10: MyEnergyPro™

Ameresco recommends implementing the MyEnergyPro™ (MEP) software suite for TMWRF to better monitor the energy and utility use at the plant. MEP is a suite of web-based energy information products developed by Ameresco to provide clients with an integrated tool to monitor utility consumption. Using MEP, TMWRF can view real-time energy consumption and renewable generation on its own unique MEP site. Historical utility and savings data can be viewed in charts and graphs and exported to Microsoft® Excel for further analysis. Using the built-in variance report, TMWRF can identify potential billing errors. The software also includes alarm and forecast modules with easily customizable settings and algorithms.

1.3.2 Other Measures Considered

The seven ECMs included in the project are only a subset of a larger set of ECMs developed during the audit. There are additional ECMs considered and developed that were ultimately not included in the project for various reasons; for many of these ECMs, the economics were not attractive enough. Some process-related ECMs were not included because of incompatibility with the proposed process modifications. Some of the major ECMs that were not included are described below.

> ECM 1: Centrate and RAS Reaeration Basin (CaRRB)

Ameresco considered a modification to the plant's biological nutrient removal process to reduce electricity consumption at the nitrification towers, and to reduce methanol consumption at the fluidized bed reactors. The process modification considered is the CaRRB process. Approximately 30 percent of the ammonia load to the nitrification towers is introduced by recycling the ammonia-concentrated centrate-stream to the main process. The modification includes retrofit of existing Phostrip tanks into a CaRRB to treat the centrate before returning it to the main process.

There are multiple potential benefits of this process:

- Increased capacity at a lower cost. The solids are inventoried at the RAS concentration which results in higher solids retention time (SRT) values with smaller volumes.
- Improved nitrification. The CaBBR process provides a steady seeding of nitrifiers to the main process allowing improved nitrification at a lower SRT.

In TMWRF, the CaRRB process would reduce the ammonia load to the Nitrification Towers, ultimately reducing the number of Nitrification Towers in service, and generating energy savings related to reduced aeration and flow recirculation. More importantly, the CaRRB process would reduce the nitrate load to the fluidized bed reactors with significant methanol savings.

While promising, after engineering analysis, we found that the CaRRB process has negative interactive effects with ECM 2: Centrate Nutrient Recovery and ECM 4A: Biogas Cogeneration System. The Pearl process in ECM 2 will consume Alkalinity in the centrate. Because of this deficiency in centrate Alkalinity, methanol savings from CaRRB will be much less than it would have been without the Pearl process. This reduced methanol savings will be completely offset by the additional electrical energy needed by CaRBB from running an additional blower. Consuming carbon in the CaRRB process will also significantly reduce the digester gas production for the cogeneration engine in ECM 4A, which will lower the electricity and heat generation. Because of these two major interactive effects, the net cost savings from CaRRB is essentially negative. For this reason, we do not recommend implementing it at TMWRF.

> ECM 3: Full Biological Nutrient Removal (BNR)

In this ECM, Ameresco considered modifying two of the existing activated sludge aeration basins to create a full BNR process, i.e. phosphorus and nitrogen removal in the activated sludge process. The existing aeration basins are designed and partitioned for BOD oxidation and biological phosphorus removal. This ECM would add an anoxic zone and mixed liquor-recycling capabilities to aeration basins 1A and 1B. With these features, both nitrification and denitrification would be provided in the activated sludge process for the flow treated in aeration basins 1A and 1B, or about 30 percent of the total flow. This flow would be pumped directly to the fluidized bed reactors, bypassing the nitrification towers. Further nitrate reduction in the fluidized bed reactors would be still required to meet the plant effluent limits.

Implementing BNR in selected basins would reduce the overall nitrogen load to the nitrification towers and fluidized bed reactors. This load reduction would maximize savings on methanol. In addition, the flow bypass would reduce the hydraulic load to the nitrification towers, reducing pumping requirements. Overall, this ECM would potentially allow the plant to take two of the nitrification towers out of service and provide additional savings on tower ventilation, media replacement, operation, and maintenance.

Aside from the energy and cost savings, the true value of the full BNR process is to prepare TMWRF for future population growth in the area. TMWRF's discharge limit is specified in an absolute amount (e.g., milligrams of nitrogen) instead of a relative percentage (e.g, mg/L of nitrogen). This means that as the plant's influent flow increases, the limit in terms of relative percentage decreases. Eventually, the plant's existing fluidized bed reactor system will not be able to achieve this limit, and TMWRF will have to switch to the full BNR system. However, this limitation will not be reached for at least 15 years. Considering the high costs for implementing the full BNR, and the fact that TMWRF personnel will have to maintain two different processes after implementation, TMWRF decided to not include this ECM in the project.

> ECM 5: FOG Addition to Digesters

The addition of Fats, Oils, and Grease (FOG) to the digestion system can significantly improve the digester gas generation, which in turn will increase the electricity and heat production of the biogas cogeneration system. In this ECM, Ameresco considered installing a receiving station to allow FOG and other high strength organic materials to be received, processed, and fed to the existing digesters. The cogeneration facility will also be expanded to accommodate the additional digester gas production from FOG digestion. The FOG receiving station can also potentially generate revenue stream to TMWRF from disposal fees of the organic materials.

During the development, Ameresco worked together with TMWRF and City of Reno to identify reliable and consistent sources of FOG that can be used for this ECM. Unfortunately, FOG is a high value commodity in the region, and there is a strong demand for it. Multiple local companies already secured the high value brown grease to produce biodiesel. Manure from local dairy farms may be another source of fuel for this ECM, but manure is a poor FOG source with very low gas yield.

We do not recommend implementing this ECM at this time because there is no reliable source of FOG. However, we encourage TMWRF to revisit it in the future as conditions change. Increasing the digester gas production to increase electricity and heat production at the cogeneration facility will be an integral component for TMWRF's long term goal to achieve a net-zero energy plant.

> ECM 8A: Solar PV System

Ameresco considered installing a small scale solar PV array to offset electricity use at TMWRF. We considered installing a 198 kW DC solar PV system on the north berm of the equalization pond. The proposed array will be tied to the electric service serving the Warehouse/Maintenance and Training Building. The system will generate a total of 331,733 kWh per year or 76 percent of the baseline consumption of the meter. Implementation of this ECM is on-hold pending the availability of adequate incentives from the utility company required to bring the simple payback to below 15 years.

> ECM 8B: Large Scale Solar PV System

Ameresco considered installing a large-scale 6 MW solar PV system at TMWRF to produce electricity and reduce cost. The array considered will be installed at the flood plain west of the plant across the Steamboat Creek. Preliminary analysis suggests that the plain is large enough to accommodate the PV panels for the system. This solar PV system will provide long term electricity rate protection and predictable energy cost for TMWRF for 30 years. Because the economics are not attractive, TMWRF decided to not pursue this ECM further. Nevertheless, we encourage TMWRF to revisit this ECM in the future. Grants may become available, or the electricity rate may increase to the point where it makes sense to install a large-scale solar PV system. As with the FOG addition, this ECM will be an important component to achieve energy independence at TMWRF.

1.4 Financial Overview

Total annual savings from implementing the ECMs is $1,122,887. The annual savings is a combination of savings in electricity, chemicals, and biosolids removal savings, as well as new revenue streams for TMWRF. ***The total project investment of $25,036,589*** includes Ameresco's audit fee, payment and performance bonds, and third party consultant fees, whose services are required by Nevada Statute. Tables 1.3, 1.4, and 1.5 provide a summary of the utility and costs savings. The project proforma is provided following Table 1.5.

The payment bond serves as an assurance to the Owner that the Contractor has paid all subcontractors and material suppliers that provided services or materials for the project in full. The performance bond guarantees the physical completion of the project and a one-year warranty for the installed work. Performance and payment bonds only apply to the installation portion of the contract and do not apply to energy savings guarantees, payment of potential savings shortfalls, or maintenance provisions.

Ameresco guarantees the savings by providing measurement and verification (M&V) services at the end of construction and the annually during the subsequent 15 year performance period. M&V services will be supported by Ameresco's MyEnergyPro™ software, which Ameresco will maintain to track energy and chemical consumption and savings. Furthermore, the cash flow contains budget allocations for operations and maintenance (O&M) tasks required by new systems which require ongoing services that exceed TMWRF's existing O&M activities. TMWRF will operate and maintain the systems after installation using internal staff, third party contractors, or a combination thereof.

The analysis is generated based on TMWRF funding the project internally without third party financing. Cost for third party engineering review of the audit is included in the proforma; however, is not part of the total construction costs paid to Ameresco. TMWRF will select the consultant and directly reimburse for services provided. The proforma uses escalation rates for the various utilities (e.g., electricity) to account for projected rate increases over the 15 year performance period.

Table 1.3. Summary of Energy and Utility Savings

Energy Conservation Measure		Annual Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Methanol Savings (Gal)	Annual Alum Savings (Ton)	Annual Fertilizer Production (Ton)	Hauling Pickup Savings (Trip)	Landfill Disposal Savings (Ton)
ECM 2:	Centrate Nutrient Recovery (Ostara)	(470)	(343,085)	29,895	1,155	562	108	2,474
ECM 4A:	850 kW Biogas Cogeneration System	0	5,696,190	0	0	0	0	0
ECM 4B:	Digester Domes Rehabilitation	0	0	0	0	0	0	0
ECM 6:	Dewatering System Upgrade	134	98,024	0	0	0	525	12,069
ECM 7:	Lighting System Upgrade	199	366,606	0	0	0	0	0
ECM 9:	Near-Term Dewatering Improvement	0	0	0	0	0	0	0
ECM 10:	MyEnergyPro™	0	0	0	0	0	0	0
	Totals	**(137)**	**5,817,735**	**29,895**	**1,155**	**562**	**633**	**14,543**

Table 1.4. Summary of Cost Savings by Source

Energy Conservation Measure		Annual Electricity Savings ($)	Annual Methanol Savings ($)	Annual Aluminum Savings ($)	Annual Fertilizer Savings ($)	Hauling Pick-up Savings ($)	Landfill Disposal Fee ($)	O&M Costs ($)	Total Annual Savings ($)
ECM 2:	Centrate Nutrient Recovery (Ostara)	(26,402)	53,273	444,817	140,424	10,789	28,901	24,183	675,985
ECM 4A:	850 kW Biogas Cogeneration System	343,233	0	0	0	0	0	(127,719)	215,514
ECM 4B:	Digester Domes Rehabilitation	0	0	0	0	0	0	0	0
ECM 6:	Dewatering System Upgrade	7,543	0	0	0	52,448	140,963	0	200,954
ECM 7:	Lighting System Upgrade	25,675	0	0	0	0	0	4,759	30,434
ECM 9:	Near-Term Dewatering Improvement	0	0	0	0	0	0	0	0
ECM 10:	MyEnergyPro™	0	0	0	0	0	0	0	0
	Totals	**$350,049**	**$53,273**	**$444,817**	**$140,424**	**$63,237**	**$169,864**	**($98,977)**	**$1,122,887**

Table 1.5. Summary of Construction Costs

Energy Conservation Measure	Total Annual Savings ($)	Energy/Chemical Project Cost ($)	Capital Repair Items ($)	Total Cost ($)	Utility Rebate ($)
ECM 2: Centrate Nutrient Recovery (Ostara)	675,985	6,760,860		6,760,860	0
ECM 4A: 850 kW Biogas Cogeneration System	215,514		5,116,967	5,116,967	0
ECM 4B: Digester Domes Rehabilitation	0		3,121,795	3,121,795	0
ECM 6: Dewatering System Upgrade	200,954	6,066,614		6,066,614	0
ECM 7: Lighting System Upgrade	30,434	428,761		428,761	15,995
ECM 9: Near-Term Dewatering Improvement	0		3,005,202	3,005,202	0
ECM 10: MyEnergyPro™	0	50,625		50,625	0
TOTAL	**$1,122,887**	**$13,306,860**	**$11,243,964**	**$24,550,824**	**$15,995**
Construction Period Savings	**$1,044,422**				
Simple Payback with Cogen Savings (Years)		**10.9**	**N/A**	**20.8**	
Simple Payback without Cogen Savings (Years)		**13.5**	**N/A**	**N/A**	

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Project Proforma
Truckee Meadows Water Reclamation Facility (January 10, 2014)

Initial Project Costs:	
Detailed Energy Audit	$ 149,835
Performance and Payment Bond, Permits	$ 210,930
Implementation Costs	$ 24,550,824
Total Initial Project Costs	**$ 24,911,589**
3rd Party Consultant Fee	**$ 125,000**
Net Project Costs	**$ 25,036,589**
Customer Contribution	**$ (25,036,589)**
Total Amount Financed	**$ -**

Financial Assumptions	
Term of Project (years)	15.0 yrs
Term of Financing (years)	15.0 yrs
Estimated Financing Rate	0.00%
Payments per Year (frequency)	-
Discount Rate	3.75%
Electricity Escalation Rate (annual)	2.89%
Chemical Cost Escalation Rate (annual)	2.89%
Biosolid Hauling Escalation Rate (annual)	3.19%
Biosolid Disposal Escalation Rate (annual)	2.38%
Fertilizer Sale Escalation Rate (annual)	0.00%
M&V and O&M Cost Escalation Rate (annual)	2.38%

Proforma

	Initial Values	Year 1	2	3	4	5	6	7	8	9	10
1 Electricity Cost Savings	$ 350,049	$ 360,165	$ 370,574	$ 381,284	$ 392,303	$ 403,641	$ 415,306	$ 427,308	$ 439,657	$ 452,363	$ 465,437
2 Chemical Cost Savings	$ 498,090	$ 512,485	$ 527,296	$ 542,534	$ 558,214	$ 574,346	$ 590,945	$ 608,023	$ 625,595	$ 643,675	$ 662,277
3 Biosolid Hauling Cost Savings	$ 63,237	$ 65,254	$ 67,336	$ 69,484	$ 71,700	$ 73,988	$ 76,348	$ 78,783	$ 81,297	$ 83,890	$ 86,566
4 Biosolid Disposal Cost Savings	$ 169,864	$ 173,907	$ 178,046	$ 182,283	$ 186,622	$ 191,063	$ 195,610	$ 200,266	$ 205,032	$ 209,912	$ 214,908
5 Fertilizer Sale Savings	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424
6 Total Cost Savings (Sum of Lines 1 to 5)	$ 1,221,664	$ 1,252,235	$ 1,283,675	$ 1,316,009	$ 1,349,263	$ 1,383,461	$ 1,418,633	$ 1,454,804	$ 1,492,005	$ 1,530,264	$ 1,569,611
7 Guaranteed Cost Savings	**$ 1,099,498**	**$ 1,127,012**	**$ 1,155,308**	**$ 1,184,408**	**$ 1,214,336**	**$ 1,245,115**	**$ 1,276,769**	**$ 1,309,324**	**$ 1,342,804**	**$ 1,377,238**	**$ 1,412,650**
8 Total O&M Savings	$ (98,777)	$ (101,128)	$ (103,535)	$ (105,999)	$ (108,522)	$ (111,104)	$ (113,749)	$ (116,456)	$ (119,228)	$ (122,065)	$ (124,970)
9 Stipulated Savings	$ 96,439	$ 99,111	$ 101,857	$ 104,680	$ 107,580	$ 110,561	$ 113,624	$ 116,772	$ 120,008	$ 123,333	$ 126,750
10 NV Energy Rebates (Note 4)		$ 15,995									
11 Renewable Energy Credits ($0.005/kWh)	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481
12 Total Project Savings (Sum of Lines 7 to 11)	**$ 1,125,641**	**$ 1,169,471**	**$ 1,182,112**	**$ 1,211,570**	**$ 1,241,875**	**$ 1,273,052**	**$ 1,305,125**	**$ 1,338,121**	**$ 1,372,065**	**$ 1,406,986**	**$ 1,442,910**
13 TMWRF Future Years CIP Contribution											
14 Total Project Funds Available (Line 12 + Line 13)	**$ 1,125,641**	**$ 1,169,471**	**$ 1,182,112**	**$ 1,211,570**	**$ 1,241,875**	**$ 1,273,052**	**$ 1,305,125**	**$ 1,338,121**	**$ 1,372,065**	**$ 1,406,986**	**$ 1,442,910**
15 Payments for Financing Equipment		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
16 Payments from CIP Contribution											
17 Payments for Measurement and Verification Services	$ 38,665	$ 39,585	$ 40,527	$ 41,492	$ 42,480	$ 43,491	$ 44,526	$ 45,586	$ 46,671	$ 47,782	$ 48,919
18 Payments for My Energy Pro Services	$ 9,375	$ 9,598	$ 9,827	$ 10,060	$ 10,300	$ 10,545	$ 10,796	$ 11,053	$ 11,316	$ 11,585	$ 11,861
19 Total Payments (Sum of Lines 15 to 18)	**$ 48,040**	**$ 49,183**	**$ 50,354**	**$ 51,552**	**$ 52,780**	**$ 54,036**	**$ 55,322**	**$ 56,639**	**$ 57,987**	**$ 59,367**	**$ 60,780**
20 Net Annual Benefit (Line 14 - Line 19)		**$ 1,120,288**	**$ 1,131,758**	**$ 1,160,017**	**$ 1,189,095**	**$ 1,219,016**	**$ 1,249,803**	**$ 1,281,482**	**$ 1,314,078**	**$ 1,347,619**	**$ 1,382,130**
21 Cumulative Cash Flow	**$ 19,859,644**	$ 1,120,288	$ 2,252,046	$ 3,412,063	$ 4,601,159	$ 5,820,175	$ 7,069,978	$ 8,351,460	$ 9,665,538	$ 11,013,157	$ 12,395,288
22 Net Present Value of Cash Flow	**$ 14,728,565**										

Line #	11	12	13	14	15	Totals
1 Electricity Cost Savings	$ 478,888	$ 492,728	$ 506,967	$ 521,619	$ 536,694	$ 6,644,933
2 Chemical Cost Savings	$ 681,417	$ 701,109	$ 721,372	$ 742,219	$ 763,669	$ 9,455,174
3 Biosolid Hauling Cost Savings	$ 89,327	$ 92,177	$ 95,117	$ 98,152	$ 101,283	$ 1,230,702
4 Biosolid Disposal Cost Savings	$ 220,023	$ 225,259	$ 230,621	$ 236,109	$ 241,729	$ 3,091,390
5 Fertilizer Sale Savings	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 140,424	$ 2,106,360
6 Total Cost Savings (Sum of Lines 1 to 5)	$ 1,610,079	$ 1,651,697	$ 1,694,501	$ 1,738,523	$ 1,783,798	$ 22,528,560
7 Guaranteed Cost Savings	**$ 1,449,071**	**$ 1,486,528**	**$ 1,525,051**	**$ 1,564,671**	**$ 1,605,419**	**$ 20,275,704**
8 Total O&M Savings	$ (127,945)	$ (130,990)	$ (134,107)	$ (137,299)	$ (140,567)	$ (1,797,663)
9 Stipulated Savings	$ 130,262	$ 133,871	$ 137,580	$ 141,392	$ 145,310	$ 1,812,690
10 NV Energy Rebates (Note 4)						$ 15,995
11 Renewable Energy Credits ($0.005/kWh)	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 28,481	$ 427,214
12 Total Project Savings (Sum of Lines 7 to 11)	**$ 1,479,869**	**$ 1,517,890**	**$ 1,557,005**	**$ 1,597,245**	**$ 1,638,643**	**$ 20,733,940**
13 TMWRF Future Years CIP Contribution						$ -
14 Total Project Funds Available (Line 12 + Line 13)	**$ 1,479,869**	**$ 1,517,890**	**$ 1,557,005**	**$ 1,597,245**	**$ 1,638,643**	**$ 20,733,940**
15 Payments for Financing Equipment	$ -	$ -	$ -	$ -	$ -	$ -
16 Payments from CIP Contribution						$ -
17 Payments for Measurement and Verification Services	$ 50,083	$ 51,275	$ 52,495	$ 53,744	$ 55,023	$ 703,679
18 Payments for My Energy Pro Services	$ 12,143	$ 12,432	$ 12,728	$ 13,031	$ 13,341	$ 170,618
19 Total Payments (Sum of Lines 15 to 18)	**$ 62,226**	**$ 63,707**	**$ 65,223**	**$ 66,775**	**$ 68,364**	**$ 874,297**
20 Net Annual Benefit (Line 14 - Line 19)	**$ 1,417,643**	**$ 1,454,183**	**$ 1,491,782**	**$ 1,530,470**	**$ 1,570,279**	**$ 19,859,644**
21 Cumulative Cash Flow	$ 13,812,931	$ 15,267,113	$ 16,758,895	$ 18,289,365	$ 19,859,644	

Notes:

1. *This cash flow reflects an estimated tax exempt lease rate of 0%. The actual rate will increase or decrease based on market conditions and customer credit rating at the time of lease funding.*
2. *Revenues are based on current utility rate structures and usage information provided for purposes of this project.*
3. *The performance and payment bonds apply only to the installation portion of the contract and do not apply in any way to energy savings guarantees, payments or maintenance provisions, except that the performance bond shall guarantee that the installation will be free of defective materials and workmanship for a period of 12 months following completion and acceptance of the work*
4. *The amount of the utility rebate(s) are not guaranteed. The final rebate amount will be determined by the utility company.*
5. *Electricity escalation rate is calculated based on NIST Energy Price Indices for commercial electricity for census region 4. A copy of the table is included in the FGOA Appendix.*
6. *Chemical cost escalation rate is assumed the same as electricity escalation rate.*
7. *Biosolids hauling cost escalation rate is based on transportation fuel price escalation. It is calculated using U.S. EIA Independent Statistics and Analysis data for 2014 to 2030.*
8. *Biosolids disposal cost escalation rate is based on Nevada CPI increases from 2002 to 2012. Data is from U.S. Dept of Labor - Bureau of Labor and Statistics.*
9. *O&M and M&V costs escalation rates are based on Nevada CPI increases from 2002 to 2012. Data is from U.S. Dept of Labor - Bureau of Labor and Statistics.*

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1.4.1 Project Benefits

Implementing the ECMs in the project will provide the following benefits to TMWRF:

- Reduce electricity consumption by 5,817,735 kWh and $350,049 per year.
- Reduce methanol consumption by 29,895 gallons and $53,273 per year.
- Reduce alum consumption by 1,155 dry tons and $444,817 per year.
- Decrease TMWRF's total biosolids hauling and disposal costs by $233,101 per year.
- Installing the Ostara side stream treatment process will produce commercial-grade fertilizer that will generate $140,424 in annual revenue for TMWRF.

In addition to the above monetary benefits, the project will also help TMWRF address outstanding operational issues and position TMWRF for future growth.

- The side stream treatment will increase stability of the treatment process and will provide TMWRF with a better nutrient removal system so TMWRF can more readily meet discharge permit requirements.
- Installing the biogas cogeneration system will help TMWRF address EPA's environmental concerns from flaring the digester gas.
- Rehabilitating the digester domes will stop gas leaks from the digesters and prevent damaging corrosion at the nearby main electrical switchgear.
- The project will upgrade and rehabilitate TMWRF's dewatering system that is at the end of its life cycle.
- Electricity savings from the project will help TMWRF take a significant step towards the long-term net zero energy goal for the plant.

There are environmental benefits from implementing the project as well. In terms of pollution reduction, energy savings from the project will provide the following:

- Avoid the production of 4,820 tons of Carbon Dioxide, 5,562 pounds of Sulfur Dioxide, and 8,860 pounds of Nitric Oxide per year.
- This reduction in Carbon Dioxide generation is equivalent to removing 814 cars from the road, or powering 582 homes per year.

1.5 Path to Energy Independence

As part of the audit, TMWRF requested that Ameresco investigate ways to achieve its long-term net zero energy goal at the plant. Based on our preliminary analysis, this goal is achievable via a combination of energy efficiency and on-site renewable energy generation. Figure 1.1 illustrates the incremental steps that TMWRF may take to make the plant energy independent. The steps are as follows:

1. Use digester gas for heating
2. Implement the ESCO project
3. Install a second biogas cogeneration engine
4. Add FOG to the digesters
5. Install a large scale solar PV system.

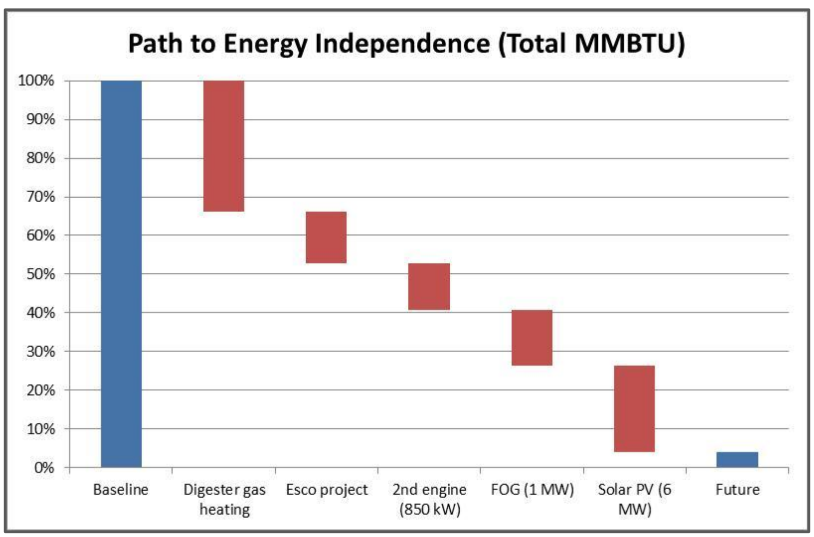


Figure 1.1. Long Term Plan to Achieve Energy Independence at TMWRF

Total baseline energy use at TMWRF in FY11/12 is 159,055 MMBTU per year, of which 53,895 MMBTU is from heating needs and 105,160 MMBTU from electricity uses. Should TMWRF implement all of the proposed steps in the plan, TMWRF will be able to supply up to 96% of its total energy needs.

> Step 1: Use Digester Gas for Heating

TMWRF has already implemented the first step in the plan, which is to use digester gas for heating. TMWRF has five digester gas boilers that directly convert the gas to heat. Most of the heat produced is used at the digester tanks, while the rest is used for building heating. Using the digester gas produced from treatment process for heating avoids the use of conventional fossil fuel. This direct use of digester gas reduces the plant's total energy use by approximately 34%.

> Step 2: Implement the ESCO Project

The ESCO project developed in this audit will reduce electricity use at the plant, primarily from installing the biogas cogeneration system. There are additional electricity savings from using higher efficiency centrifuges, cake pumps, lighting, etc. In total, all electricity savings from implementing the ESCO project will reduce energy use at the plant by another 13%. Combined with Step 1, once the project ECMs are constructed, TMWRF will achieve 47% energy independence at the plant.

> Step 3: Install a Second Biogas Cogeneration Engine

As will be described in Section 4 and as part of the ESCO project, we plan to install only one cogeneration engine. The main reason for this is because there is not enough digester gas available to operate a second engine during the winter. Heating needs at the plant in winter limits the amount of gas that can be used to produce electricity. However, in summer there will be excess gas that can be used for electricity production. TMWRF may install a second engine and run it when heat demand is low to further reduce plant's electricity needs.

> Step 4: Add FOG to the Digesters

Step 4 in the plan is to implement the FOG addition measure (ECM 5) that was considered in the audit but not included in the project. Adding FOG to the digestion process will boost the amount of digester gas that can be used to produce heat and electricity. The increased production will necessitate adding a third cogeneration engine, or replacing existing ones with larger units. The main challenge in implementing this step will be in identifying and securing a reliable source of FOG for the plant. At the time of this audit, there was little FOG available for plant's use, as there were already local businesses that absorbed much of the local supply. However, as population grows, there may be more FOG available in the future.

> Step 5: Large Scale Solar PV System

The last major step for TMWRF to achieve energy independence at the plant will be to install the large scale solar PV system described previously (ECM 8B). The measure contemplates a 6 MW solar PV system installed at the flood plain across Steamboat Creek. This ECM is not included in the project because the economics are not attractive and there is no grant or rebate available to offset the upfront cost. Nevertheless, solar PV system price continues to decline while electricity price keeps increasing. This will make the economics much more attractive in the future. TMWRF may also opt to build the PV system in smaller increments over time to lighten the upfront cost burden.

Steps 3, 4, and 5 are the additional steps that TMWRF need to take to achieve complete energy independence. Because the economics are not attractive at this point, we have not included them in the ESCO project. Nevertheless, TMWRF should consider incorporating them into its future capital planning if TMWRF wants to achieve energy independence for the plant.

2.0 Facility Background

2.1 Site Overview

TMWRF is owned and operated by the cities of Reno and Sparks in Washoe County, Nevada. The facility serves the wastewater treatment needs of the cities and parts of unincorporated Washoe County. Reclaimed water from the TMWRF is discharged to Steamboat Creek, a major tributary to the Truckee River; however, some of the reclaimed water is directed to sites for direct use during peak irrigation months. Presently, TMWRF operates at 31 million gallons per day (MGD) with a peak permitted capacity of 44 MGD.

The initial facility was constructed in the mid- to late-1960s, but has since had several modifications, additions, and overhauls. Notable projects include the 1978 increase in primary and secondary capacity, 1985 capacity increase and tertiary treatment installation, 2000 aeration tank improvements, and 2001 nitrification tower installations. The latest plant upgrade was completed in 2007 with the overhaul and replacement of end-of-life equipment.

2.2 Treatment Processes

Wastewater treatment requires two primary processes: liquid and solids treatment. Please reference Figure 2.1 for a schematic diagram of these processes. A description of each stage in the process follows Figure 2.1.

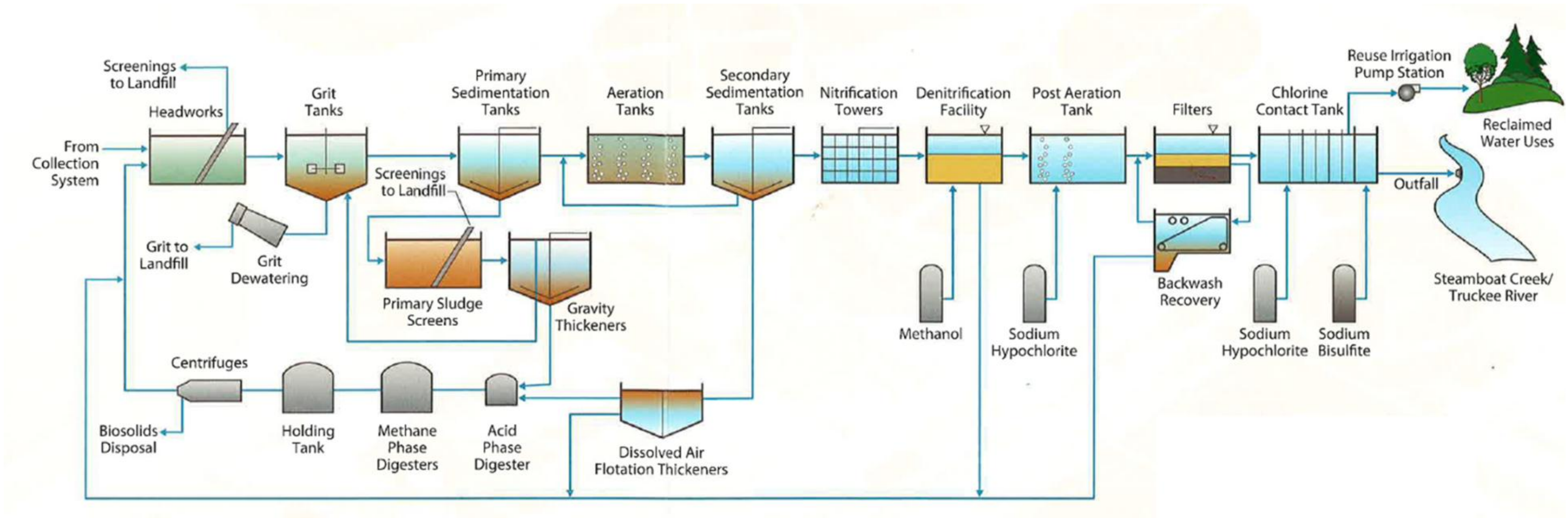


Figure 2.1. Schematic Diagram of Wastewater Treatment Process

> Step 1: Screening and Grit Removal

Raw wastewater entering the plant is screened at the headworks and falls into the raw sewage wet well. Screenings from the headworks are diverted to the landfill, while wastewater from the wet well is pumped to the primary clarifiers by four 500 horsepower (HP) motors with variable speed drives (VSDs). Prior to the primary clarifiers, two hydrocyclone grit separators remove sand and heavy organic solids from the wastewater. Separated grit is dewatered and then hauled to the landfill.

> Step 2: Primary Sedimentation

Primary sedimentation takes place at seven primary clarifier tanks. Each tank is equipped with a 15 HP scum pump and a 15 HP sludge pump, each of which is equipped with a VSD. Primary sludge from the clarifiers is diverted to the gravity sludge thickener, while the primary scum is directed to the sludge digesters. Primary sludge is screened prior to entering the sludge thickener. Screenings from the sludge thickener are diverted to the landfill.

> Step 3: Aeration

After primary sedimentation, the wastewater is directed to one of the five primary aeration tanks. Each of these aeration basins is equipped with an anaerobic zone followed by aerated zones to allow for the digestion of dissolved and suspended matter. Fine bubble aeration is provided by four 900 HP centrifugal Turblex blowers. Aerated wastewater from the tanks is then pumped to the secondary clarifiers.

Aeration tank at TMWRF

> Step 4: Secondary Sedimentation

Activated sludge and treated wastewater are separated at the seven secondary clarifiers. Each clarifier is equipped with two variable speed 30 HP sludge pumps. A portion of the activated sludge is returned to the aeration tanks, while the other portion is directed to the dissolved air flotation thickeners. Water from the secondary clarifiers is then pumped to the nitrification towers for nitrogen removal. The facility has a 4.4 million gallon secondary effluent flow equalization basin to allow for flow equalization between the secondary clarifiers and the nitrification towers if required; however, the basin is not currently in use.

> Step 5: Nitrification

Secondary clarifier effluent enters the nitrification wet wells and is distributed to the six nitrifying trickling filter towers by four 200 HP variable flow vertical turbine pumps. Eight 25 HP centrifugal blowers at Towers 1 through 4 and four 10 HP blowers at Towers 5 and 6 provide the aeration required at the tower media. Two 100 HP tower treatment pumps are available to distribute treated water as required for the snail control sequence. Snail shells are removed by screening the nitrification tower effluent.

Nitrification towers

> Step 6: Denitrification

Nitrification tower effluent is distributed to the denitrification reactor by four 400HP variable flow denitrification feed pumps. Methanol is injected into the influent to provide the carbon necessary for the denitrification reaction. Three 5 HP media washing pumps operate continuously to remove built-up biomass at the reactor media. The biomass is returned to the headworks for treatment. Reactor effluent is directed to the post-aeration basin.

> Step 7: Post-Aeration

Additional aeration increases the oxygen content required to meet the final effluent permit standard of five milligrams per liter (mg/L). The aeration process relies on the jet aeration process with coarse bubble diffusion distribution. Post-aeration basin effluent is filtered by 12 dual-media down-flow filters. The filters require periodic backwashing to maintain effectiveness. Two 200 HP centrifugal pumps provide backwash capabilities. Two 60 HP waste backwash pumps redirect the waste backwash to the backwash clarifier.

> Step 8: Disinfection

Disinfection is provided at the chlorine contact basin where sodium hypochlorite is injected into the effluent. To achieve the discharge permits requirement for complete dechlorination, sodium bisulfate is injected and mixed at the dechlorination basin. The dechlorinated effluent then flows to the outfall structure. A 10 HP foam dissipation spray system is located at the outfall channel.

2.2.1 Solids Treatment

> Step 1: Primary Sludge Thickening

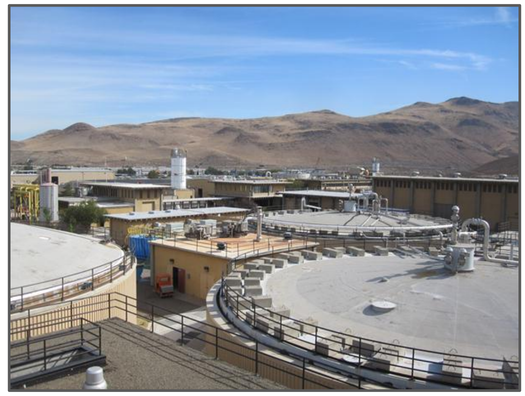
Sludge from the primary clarifiers is screened and thickened by gravity thickeners. Screened material is hauled to the landfill, while thickened sludge is fed to the acid phase digester (APD). Thickened primary sludge going to the APD typically contains 3 to 3.5 percent solids.

> Step 2: Dissolved Air Floatation Thickening

Sludge from the secondary clarifiers is pumped to the dissolved air floatation thickening (DAFT) unit for thickening. The DAFT is equipped with three 60 HP pressurization pumps, although typically only one pump is used. Compressed air from the plant air system is injected to the DAFT unit for the thickening process. Thickened secondary sludge from the DAFT is pumped to the APD for digestion. Typical solids content of the sludge from DAFT is 5 to 5.5 percent.

> Step 3: Sludge Digestion

Thickened sludge from the gravity thickener and DAFT is pumped to the APD by one of three 20 HP pumps. After anaerobic digestion at the APD, the sludge is sent to the five methane phase digester (MPD) tanks for further digestion. Anaerobic digestion at the APD generates approximately 800 to 1,000 standard cubic feet per hour (SCFH) of biogas with 95 percent carbon dioxide (CO_2) content. The MPD generates between 30,000 to 33,000 SCFH of biogas containing 60 percent methane. Approximately half of the MPD biogas is used in three hot water boilers and five sludge heaters to generate hot water, as well as provide heat to the digesters and buildings. The rest of the MPD biogas is flared with the APD gas.



Methane digesters with digester gas collectors on the top.

> Step 4: Dewatering and Disposal

Stable sludge from the digesters is transferred to the dewatering facility prior to final disposal. Dewatering is done by solid bowl centrifuges with hydraulic back drives. The main drive motors for the centrifuges are 175 HP each. Four sludge cake silos house dewatered sludge cake until it is transferred to waste removal trucks for final disposal at the Lockwood Landfill. Captured liquid from dewatering is directed to the flocculation basin to remove phosphor content via alum mixing. The liquid is then returned to the headworks to start the treatment process again.

2.3 Facility Buildings

Process-related basins and towers occupy most of TMWRF; however, there are 31 support buildings as listed in Table 2.1. Many of these buildings house pumps, chemicals, and other equipment involved in the treatment process. Several of the facilities, including the Administration, Laboratory, and Training Buildings, provide office space for a control center, administrative offices, conference rooms, laboratories, and other purposes. Additionally, under- and above-ground tunnels connect the buildings. These tunnels are labeled Galleries A to K; some are used to house additional processing equipment. Figure 2.2 depicts the general layout of the treatment plant and shows the facilities affected by the 2007 facility upgrades.

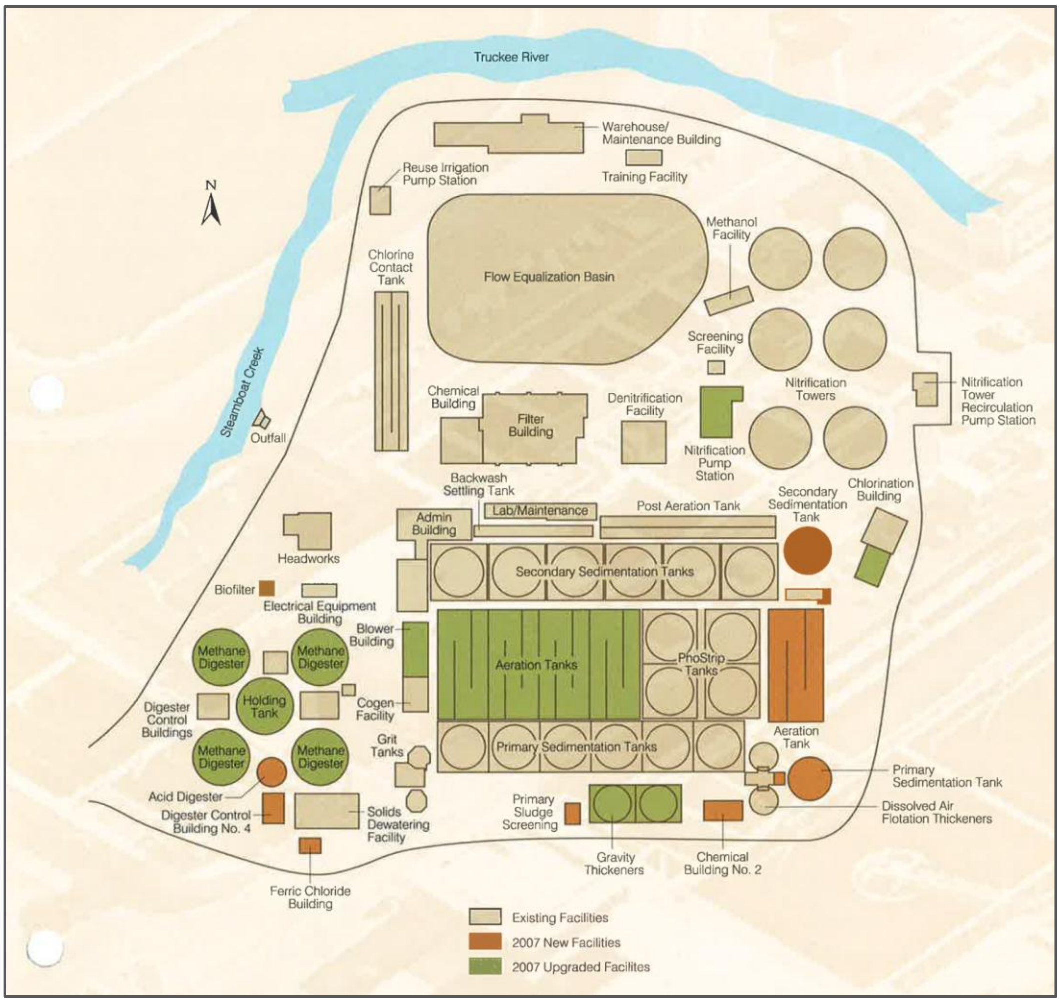


Figure 2.2. TMWRF Layout

Table 2.1. List of Buildings at TMWRF

Building	Floors	Square Footage (approximate)
Administration Building	2	4,000
Blower Building	1	5,000
Chemical Building	2	7,500
Chemical Building No. 2	1	4,000
Chlorination Building	1	5,000
Chlorine Contact Building	1	500
Cogen Building	1	2,000
DAFT Building	1	1,500
Denitrification Building	1.5	10,000
Digester Control Building No. 1	2	4,000
Digester Control Building No. 2	2	4,000
Digester Control Building No. 3	1	1,500
Digester Control Building No. 4	2	5,000
Electrical Equipment Building	1	1,500
Ferric Chloride Building	1	1,000
Filter Facility	2.5	10,000
Galleries A - K	1	20,000
Grit Removal Building	2	4,000
Headworks Building	2	4,000
Laboratory Building	2	20,000
Maintenance/Warehouse Building	2	10,000
Methanol Facility	1	500
Nitrification Pump Station	2.5	7,500
Nitrification Tower Recirculation Pump Station	1	200
Primary Sludge Screening Building	2	1,200
RAS Pump Building	3	1,000
Reuse Irrigation Pump Station	2	2,500
Screening Facility	1	0
Solids Dewatering Building	2.5	15,000
Storage Building	1	2,000
Training Building	1	1,500
	Total	**155,900**

Notes:

DAFT = Dissolved Air Flotation Thickener

RAS = Return Activated Sludge

2.3.1 Administration Building

> Building Description

The Administration Building was built in in the mid-1960s. The building is a two-story concrete structure with concrete and a stucco façade. The building is approximately 4,000 square feet (SF). The first floor consists of the control, server, break, and locker rooms, as well as the lobby. The second floor consists of six offices and a conference room. There are two restrooms on the second floor. Glazing is double pane throughout. The Administration Building reportedly operates 24 hours a day, 365 days a year.

> HVAC Systems

The primary source of conditioning for the Administration Building is one air handing unit (AHU) located in a dedicated mechanical room on the second level. The AHU is multi-zone unit serving five zones in the building. Heating for the AHU is provided by a heating water coil, and cooling is provided by a direct expansion (DX) cooling coil. The compressor is located at the AHU, while the remote condenser is located on the roof. The unit is a constant volume unit with a 7.5 HP motor. In addition to this multi-zone AHU, there is a rooftop unit (RTU) serving the northwest offices on the second floor, and there are two, 2-ton mini-split DX units serving the computer server room on the first floor.

The heating water loop at the Administration Building is fed by the main heating water loop that serves the TMWRF. Biogas-fed hot water boilers provide heating for the hot water loop.

During the energy audit, Plant Operations informed Ameresco that the existing multi-zone AHU and RTU will be replaced in 2013 because they are at the end of their service lives. The multi-zone AHU will be replaced with five single-zone AHUs with split-DX and hot water coils. Condensing units for the new AHUs will be located on the roof. The existing RTU will be replaced with a similar RTU with a packaged DX for cooling and hot water coils for heating. A new fan coil unit (FCU) will be installed for the west office on the second floor to provide additional cooling. This FCU will also have a split condensing unit on the roof and a hot water coil.

The planned upgrades will also replace existing pneumatic thermostats for the multi-zone AHU and RTU in the building with programmable thermostats.

> Lighting Systems

Lighting fixtures in the building are configured in a variety of styles and lamp combinations. The predominant lighting in the building consists of 32 W T8 lamps with electronic ballasts, which account for 90 percent of the fluorescent lighting. There are some T12 lamps with magnetic ballasts serving the offices. Most fixtures have two lamps per fixture; a few have three or four lamps. Exterior lighting is primarily High Pressure Sodium (HPS).

> Plug Load Equipment

The Administration Building consists of a mechanical room, server room, offices, control room, locker room and a break room. Plug load equipment in this building is comprised of computers, monitors, printers, copiers, fax machines, telephones, and other office equipment. The staff lounge room is equipped with a refrigerator, microwave oven, coffeemaker, toaster ovens, and other miscellaneous plug loads.

> Plumbing Systems

The Administration Building is equipped with potable hot and cold domestic water. Domestic water is used for the water closets, lavatories, sinks, showers, and service sinks. A heat exchanger is used to generate domestic hot water from the primary hot water loop in the TMWRF.

2.3.2 Blower Building

> Building Description

Turblex blowers 1- 3

The Blower Building is a one-story building with a mezzanine. Structurally, the building is the same as the Administration Building with concrete construction and a stucco façade. The rooms also have mechanical rollup doors for large equipment access. The 5,000 SF (approximately) building is separated into two rooms.

The first room houses three of the Turblex blowers serving the aeration basin, while the fourth Turblex blower is located in the second room. Electrical switchgears for the blowers are also located in the two rooms. The first room in the building has a high, 40 foot ceiling with glass-block windows near the ceiling for natural light, while the second room has a lower, 25 foot ceiling.

> HVAC Systems

The first room in the building has three axial fans on the roof that supply outside air for the blowers. A fresh air supply fan for the fourth blower in the second room is located on the wall. These fans run continuously.

Two hot water pumps (P15101 and P15102) are located in the first room of the building. These pumps are circulation pumps for heat loop zone two. They are 10 HP pumps with variable frequency drives (VFDs). One pump was running at the time of the site surveys.

Two Trane Torrivent heating and ventilation AHUs with no cooling capability are located on the mezzanine level of the building. AHU HV15071 provides heating and ventilation for the Blower Building. It is a single-zone, constant-volume air circulation unit with a hot water coil for heating only. A two-way valve controls the hot water flow; the unit is controlled by a wall-mounted, non-programmable thermostat. The second AHU, HV15072, is a heating and ventilation unit for Gallery B located behind the building. It is a 100 percent outside air unit with hot water heating only. Outside air for the unit is ducted from a wall opening in the Blower Building. A two-way hot-water valve for heat regulation is controlled by a Honeywell non-programmable thermostat in the Gallery.

> Lighting Systems

Both the first and second rooms in the building have high windows near the ceiling for natural daylight. In addition, the first room has fourteen 4 foot pendant fixtures on the ceiling for additional light, each of which has six T5 high output (HO) fluorescent lamps. The second room in the building has 4 foot wrap fixtures containing two 32 W T8 fluorescent lamps.

2.3.3 Chemical Building

> Building Description

The Chemical Building is a one-story steel frame structure with a basement located across the Administration Building. The building has metal siding interior and exterior walls and a pitched metal roof. There is insulation around the walls and the ceiling. The building has a high, 30 foot ceiling with a large mechanized rollup door for large equipment access. The Chemical Building is connected to the Filter Gallery through a basement tunnel.

Aluminum bisulfate tanks

The ground floor of the building is occupied primarily by two aluminum sulfate tanks and one sodium bisulfate tank used in the treatment process. Two sodium bisulfate feed-pumps are also located in the building. Two Ingersoll-Rand compressors supply compressed air to the plant.

Located on the ground floor, the boiler room has two custom-built hot water boilers with Webster Cyclonetic burners rated at 2,000 million British thermal units per hour (MBH). The units use digester gas from the treatment process as fuel. Additionally, two 15 HP hot water pumps (P83101 and P83102) are located inside the boiler room. These pumps circulate hot water from the boiler room to other parts of the plant. During the walkthrough, one boiler and one pump were running.

The basement of the Chemical Building houses various pumps. Three 100 HP pumps without VFDs rated for 2,300 GPM and 129 foot operation service the Number Two (No. 2) water loop. Two strainers for the No.2 water loop are also in the basement. Two 7.5 HP PACO pumps service the Number Three (No. 3) water loop. The pumps do not have VFDs and are rated for 100 GPM and 137 feet of head.

Additionally, a room at the corner of the basement houses two blowers for backwash operation in the Filter Gallery. These 150 HP centrifugal blowers were manufactured by United Blowers Inc. In addition to the pumps and blowers, the Chemical Building's basement also houses the motor control center (MCC) for the equipment.

> HVAC Systems

Ventilation for the ground floor of the building is provided by three exhaust fans on the roof, with wall cutouts for fresh air intake. Heating for the ground floor is provided by three hot water heaters on ceiling in the corner of the room. All of the units have two-way control valves on the hot water lines and manual thermostats on the walls.

There is no dedicated heating and ventilation unit for the boiler room aside from the boiler's exhaust stacks to the roof and the wall cutouts for fresh air intake for the boilers. The boiler room has no mechanical cooling.

The building's basement has three fans with ducted air supply for ventilation. The fans take fresh air from the ground floor above and rely on a pressure differential for relief back to the ground floor via ceiling grilles. Heat for the basement is supplied by a hot water unit heater with a wall-mounted manual thermostat. The backwash blower room has its own ventilation fan, but it does not have a unit heater.

> Lighting Systems

The ground floor of the building has windows and skylights for natural daylight. For additional lighting, there are twelve low-bay fixtures with metal halide lamps and four fluorescent light fixtures. The fluorescent fixtures are 4 foot fixtures, each with two 32 W T8 lamps and a wire cage guard for protection. The boiler room has two 4 foot vapor-tight fixtures with two 32 W T8 lamps each. The basement has eleven 4 foot fixtures, each of which has an industrial wire cage and two 32 W T8 fluorescent lamps. The building's exterior has wallpack fixtures with HPS lamps.

2.3.4 Chemical Building No. 2

> Building Description

Chemical Building Number Two (No. 2) is a one-story concrete building next to the DAFT Building. The building is used as the primary storage facility for the dewatering polymer and ferric chloride. There are three main rooms in the building: the polymer storage room, ferric chloride storage room, and an electrical room in between the two rooms. Both the polymer storage and ferric chloride storage rooms have high ceilings with a basement sump. The polymer storage room has a mezzanine that houses the AHUs for the building.

Two large polymer storage tanks, two smaller polymer aging tanks, and two polymer solution pumps are located in the polymer storage room. The polymer solution pumps are 5 HP pumps with VFDs. There are also three polymer blenders for polymer transfer from the tanks. The ferric chloride storage room has two large storage tanks for the chemical. One ½ HP transfer pump is used to fill the tank with the ferric chloride. Four ferric chloride feed pumps housed in the room supply the chemical to the treatment process. These pumps are segregated from the rest of the room because of the corrosive nature of the chemical.

The building's electrical room houses the electrical cabinets for the process equipment. In addition, a Liebert Infinity alarm system rack is located in the room. The Liebert system controls the security alarms for the plant.

Polymer (left) and ferric chloride (right) tanks in Chemical Building No. 2

> HVAC Systems

Fresh air for both the polymer storage room and the ferric chloride room is supplied by a make-up AHU on the mezzanine in the polymer storage room. It is a 100 percent outside air unit with an evaporative cooler for cooling and a hot water coil for heating. The polymer storage room has two exhaust fans on the wall for ventilation, while the ferric chloride storage room has one exhaust fan on the wall.

Cooling and ventilation for the electrical room is provided by AHU 84111, also located in the mezzanine. It is a cooling only AHU with a split DX coil and a 4-ton York condensing unit outside. Supply and return air for the room is ducted from the AHU. Outside air intake for the room is drawn through a louver in the wall to the AHU. Exhaust for the electrical room is though the polymer storage room.

> Lighting Systems

The polymer storage room and the ferric chloride room both have high bay light fixtures with 250 W metal halide lamps for interior lighting. The electrical room has pendant style 4 foot fluorescent light fixtures, each with two 32 W T8 lamps and electronic ballast per fixture. There are several wallpack fixtures with HPS lamps at the building exterior for lighting.

2.3.5 Chlorination Building

> Building Description

Chlorination Building

The Chlorination Building is a large one-story storage building at the east side of the treatment plant. It is used to store the sodium hypochlorite (bleach) and sodium hydroxide (caustic soda), both as dry chemicals and as a liquid solution, used in the treatment process. The building is divided into two main rooms: the dry storage room and the liquid storage room. There is also an electrical room between these two main rooms.

The dry storage room has four large storage tanks to store the dry sodium hypochlorite. There are two lift vehicles for transporting the dry chemicals and two rollup doors for ingress and egress to the room. The liquid solution room has two large tanks to store the liquid sodium hypochlorite solution. In addition, the room houses a large dry storage tank for the dry sodium hydroxide and a liquid storage tank for the sodium hydroxide solution. Feed pumps for transferring the liquid chemicals to and from their storage tanks are also located in this room.

The electrical room houses the electrical distribution cabinets for the exhaust fans, AHUs, and transfer pumps serving the building.

> HVAC Systems

Ventilation for the dry storage room is provided by one Reznor and one Premier AHU located on the roof. Both AHUs are 100 percent outside air units with an evaporative cooler for cooling and a hot water coil for heating. Exhaust for the room is also provided by an exhaust fan on the roof. The dry storage room has two Dayton hot water unit heaters on the ceiling for additional heat. These heaters are controlled by wall-mounted thermostats.

Similarly, ventilation for the liquid storage room is supplied by one Reznor and one Premier AHU on the roof. These units are identical to the AHUs serving the dry storage room. They are 100 percent outside air units with an evaporative cooler and a hot water coil. One exhaust fan on the roof provides exhaust for the liquid storage room. A Trane hot water heater controlled by a wall-mounted digital thermostat provides additional heat in the room.

There is no dedicated heating or cooling for the electrical room. One exhaust fan on the roof provides ventilation.

> Lighting Systems

Both the dry and liquid storage rooms have a combination of high bay light fixtures and pendant-mounted fluorescent light fixtures. The high bay fixtures house 250 W metal halide lamps, while the fluorescent fixtures each house six 32 W T8 lamps. The electrical room also has 4 foot fluorescent light fixtures with six 32 W T8 lamps and electronic ballasts.

Exterior illumination is provided by HPS lamps for floodlighting or in wallpack fixtures.

2.3.6 Chlorine Contact Building

> Building Description

The Chlorine Contact Building is a small, one-story concrete structure at the south end of the chlorine contact tank located next to the Chemical Building. During the FGOA, the building was unoccupied and not in use. However, plant operations informed Ameresco that TMWRF planned to move the chlorine injection equipment from the metal shack outside the building to the Chlorine Contact Building. A large chlorine storage tank above the building was also unused, and thus removed in October 2012.

Chlorine Contact Building and basin. The storage silo was removed in 2012.

> HVAC Systems

Ventilation for the building is provided by two wall-mounted exhaust fans on the side walls. Fresh air supply is provided by a grille on the wall. One Trane hot water unit controlled by a wall-mounted on/off switch heats the building's interior. The building has no mechanical cooling.

> Lighting Systems

Interior lighting for the building is provided by 4 foot wrapped fluorescent light fixtures. Each fixture has two 32 W T8 lamps with electronic ballasts. The light fixtures are controlled by an occupancy sensor with a timer on the wall.

2.3.7 Cogeneration Building

> Building Description

The Cogeneration (Cogen) Building is a one-story concrete and stucco building located next to the Blower Building. The building is approximately 2,000 SF with a high ceiling. The building houses an 800 kilowatt (kW) Caterpillar cogeneration engine that uses digester gas to produce electricity and hot water. However, at the time of FGOA development, the cogen facility was not in operation because of issues with H2S and Siloxane from the digester gas. The staff reports that the generator has not operated for a number of years. Instead, the excess digester gas is flared just outside of the building. One of the ECMs under consideration in this FGOA is to bring the cogeneration facility back online to produce electricity and hot water on-site using methane gas from the digesters.

Existing cogeneration system (not used).

In addition to the engine, the building houses the other components of the cogen facility. An ASCO Delta electric transfer switch monitors the electricity produced by the engine and controls the tie-in to the utility grid. Two heat exchangers on the back wall of the building capture the jacket and exhaust heat from the engine and produce hot water for plant use. Two 7.5 HP hot water pumps in the building circulate the hot water produced to other parts of the plant.

> HVAC Systems

Building ventilation is provided by one supply fan and one exhaust fan located on the roof. Fresh air for the building is ducted from the supply fan along the back wall of the building, while the exhaust fan ventilates through the ceiling. Both fans run continuously. Three relief grilles on the building walls maintain building pressure.

Building heating is provided by one Trane unit heater at a corner ceiling. The unit has a hot water coil with a two-way valve for control. The building has no mechanical cooling.

> Lighting Systems

Natural day lighting is provided by five skylights on the ceiling. There are no windows in the building. In addition, there are eight 4 foot high bay fixtures with four T5 HO fluorescent lamps per fixture.

2.3.8 DAFT Building

> Building Description

The DAFT Building is a one-story concrete building located at the southeast corner of the facility. The building is part of the DAFT process that thickens the waste-activated sludge (WAS) from the secondary sedimentation tanks before the digestion process. Two large DAFT tanks outside the building serve as the basins used for the process, while the process equipment is located inside the building.

Compressed air for the DAFT process is supplied by one Ingersoll-Rand air compressor inside the building. It has a 100 HP compressor generating 411 cubic feet per minute (CFM) of compressed air. Another component of the compressed air system is an Ingersoll-Rand air dryer and an air storage tank in the room. The air dryer is a desiccant-based cooler with no separate condensing unit.

Ingersoll-Rand air compressor for DAFT process.

Three constant speed 60 HP WAS pumps with no VFDs are located inside the building. One pump is required per DAFT tank; the third WAS pump serves as backup. During the walkthrough, two WAS pumps were in operation, while pump number one was disassembled for maintenance. Thickened WAS from the process is stored in two retention tanks before being pumped to the acid digester. Three Thickened WAS (TWAS) pumps in the room are used for the transfer. The TWAS pumps are 20 HP with VFDs. During the walkthrough, two TWAS pumps were running at 70 percent speed.

An annex next to the DAFT pump room houses the sludge and scum pumps for the newest primary sedimentation tank. The new tank was installed during the 2007 expansion and is located just outside the building. Like the other primary sludge and scum pumps, each unit is 15 HP with VFDs.

> HVAC Systems

Ventilation for the main pump room is provided by one exhaust fan on the wall. Fresh air supply is taken from a wall grille. Heating is supplied by one Trane hot water heater with a two-way valve for control mounted on the ceiling. The unit is controlled by a wall-mounted thermostat.

Heating and make-up air for the annex is provided by AHU 24103 hung on the ceiling. It is a 100 percent outside air unit with a hot water coil for heating and a wall-mounted thermostat. An exhaust fan on the wall provides exhaust for the room.

> Lighting Systems

Interior lighting for the building is primarily fluorescent. The room has several 4 foot vapor-tight light fixtures hung from the ceiling. Each fixture has two 32 W T8 fluorescent lamps with electronic ballasts. These fixtures are controlled by occupancy sensors on the wall.

2.3.9 Denitrification Building

> Building Description

The Denitrification Facility is a one-story concrete building with a basement located between the denitrification tanks. The facility is used to convert nitrate nitrogen from the effluent from the nitrification towers to nitrogen gas, which is then released into the atmosphere. The ground floor of the building houses six Morris media abrasion pumps with 7.5 HP Siemens motors for the process. During the walkthrough, three of the pumps were running. MCC cabinets for the abrasion and basement pumps are also located on the ground floor.

One of the four denitrification tank.

The basement has two Morris dewatering pumps with 25 HP motors without VFDs. In addition, there are two Aurora spray water booster pumps with 25 HP motors in the basement. The denitrification process at the facility uses phosphoric acid, which is stored separately in a container outside the building.

> HVAC Systems

Heating and ventilation for the ground floor and basement of the building is provided by one McQuay AHU located on the ground floor. It is a single-zone, constant volume AHU with hot water coils for heating. The unit has no mechanical cooling.

Outside air for the building is ducted from the wall to the AHU. Supply and return air to and from the AHU are ducted along the ceiling of the ground floor and the basement. Exhaust air is ventilated from the AHU to a wall on the ground floor. Hot water flow to the AHU is regulated by a two-way valve, which is controlled by a wall-mounted Honeywell thermostat on the wall.

> Lighting Systems

The ground floor of the building has twelve vapor tight wrap fluorescent light fixtures, each with two 32 W T8 lamps. The lights are controlled by wall-mounted occupancy sensors. Similarly, the basement has fifteen vapor tight wraps fixtures, each with two 32 W T8 fluorescent lamps.

There are a total of six light poles on top of the denitrification tanks. Four of the poles have two shoebox fixtures, while two poles only have one shoebox fixture. HPS lamps are mounted in each fixture.

2.3.10 Digester Control Building No. 1

> Building Description

Sludge heaters 3 and 4 in Digester Control Building No. 1

There are four Digester Control Buildings at the complex. Digester Control Building Number One (No. 1) is a one-story concrete building with a basement located near the main entrance. The ground floor of the building is comprised of two rooms. The front room houses sludge heaters numbers three and four (No. 3 and 4) that heat the sludge in the methane digester tanks. These tanks are custom-built heaters that use digester gas as fuel and produce hot water. This room also houses a 5 HP pump sludge transfer pump (No. 5). MCC cabinets for the sludge circulation pumps and other equipment are located in this front room, as well.

A separate room at the back of the building houses three digester gas compressors which have ABB VFDs located in the electrical cabinets. During the walkthrough, only compressor No. 1 was running at 10.5 hertz (Hz).

Sludge recirculation pumps numbers three and four (No. 3 and 4) are located in the basement. They are 15 HP Vaughan pumps, which were both off during the walkthrough. Booster pumps for hot water circulation from the heaters to the digester tanks are also located in the basement. There are a total of six Armstrong hot water pumps labeled as follows:

- P34101 and P34102: 15 HP with no VFD
- P34111 and P34112: 5 HP with no VFD
- P34121 and P34122: 3 HP with no VFD

One 5 HP and one 3 HP pump were in operation during the walkthrough.

The basement also houses three digester gas filters used to clean the gas before going to the sludge heaters. These Dollinger filters (model D17060C0) are labeled F34051, F34052, and F34053. Additionally, one large air compressor, one air holding tank, and two Gormann-Rupp gas-sludge separator pumps with 2 HP motors are housed in the basement.

> HVAC Systems

Fresh air supply for the heater room on the ground floor is provided by two make-up air fans on the roof. Exhaust from the room is provided by exhaust stacks from the heaters. The room also has two hot water heater units on the ceiling controlled by wall-mounted, manual Honeywell thermostats.

The digester gas compressor room at the back on the building has one exhaust fan on the ceiling that continuously operates. Outside air intake is provided by cutouts on the wall. The room has one hot water unit heater on the ceiling for heating.

Heating and ventilation for the building's basement is provided by one Trane Torrivent AHU. The unit is single-zone with a circulation fan only and no hot water coil. Fresh and warm air for the AHU is taken from the heater room above, and the unit exhausts air through the stairway to the ground floor. The basement has no heater.

> Lighting Systems

The heater room on the ground floor has skylights for natural lighting. Additional lighting for the room is provided by pendant-style fluorescent light fixtures with two 32 W T8 lamps per fixture. The light fixtures are controlled by occupancy sensors on the wall. The compressor room at the back has HPS lamps for lighting enclosed in explosion-proof fixtures on the ceiling. Light control for the room is provided by a wall toggle switch. The basement also has two lamp 32 W T8 fluorescent fixtures with automatic occupancy sensors on the wall. The exterior of the building has one wallpack fixture with an HPS lamp.

2.3.11 Digester Control Building No. 2

> Building Description

Digester Control Building Number Two (No. 2) is a one-story concrete building located behind the Electrical Equipment Building. The building is divided into two rooms. The first room is used as an office and a dry blasting shop. There is an operator's desk in the room along with two Trimco dry blasting machines. A heater room on the other side of the building houses sludge heater number five (No. 5). Like the other sludge heaters, this heater is fueled by digester gas.

Sludge heater 5 at Digester Control Building No. 2.

> HVAC Systems

Two PACE make-up air units on the roof provide fresh air for the building. They are 100 percent outside air units with evaporative coolers for cooling; they do not have heating elements. Make-up unit ASU30701 serves the office room of the building; ASU30702 serves the heater room. Exhaust for the office and shop is provided by one roof-mounted exhaust fan EF30701. Exhaust for the heater room is provided by roof-mounted exhaust fans EF30702 and EF30703.

Heating for the office and shop is provided by one Trane hot water heater in the room. The unit has a two-way valve for hot water flow control, which in turn is controlled by a thermostat on the wall. Similarly, hot water for the heater is provided by one Reznor hot water heater in the room controlled by a wall-mounted thermostat.

> Lighting Systems

Interior lighting for the office and shop is provided by six metal halide lamps mounted on the ceiling with an explosion-proof enclosure. The heater room has five of the same light fixtures. The building's exterior has four wallpack fixtures with HPS lamps.

2.3.12 Digester Control Building No. 3

> Building Description

Sludge heaters numbers one and two in Digester Control Building No. 3

Digester Control Building Number Three (No. 3) is a one-story concrete building with a basement located across from the Cogeneration Building. The ground floor of the building houses sludge heaters numbers one and two (No. 1 and 2), as well as MCC cabinets for the pumps and other equipment in the basement. Like the other sludge heaters, these heaters use digester gas as fuel and produce hot water for heating the sludge.

The equipment housed in the basement includes:

- Vaughan sludge heater recirculation pumps numbers one, two, and five (nos. 1, 2, and 5) are located along three sides of the basement. These pumps have 15 HP motors. None of the pumps were in operation during the walkthrough.
- Two digested sludge 3 HP grinders are located at one end of the basement. One pump was operating during walkthrough.
- Three 15 HP Centrifuge feed pumps with VFDs are located in the middle part of the basement. Feed pump No. 2 was running at 58 Hz during walkthrough, while the other two were off.
- Two 3 HP hot water pumps (P32101 and P32102) without VFDs are also located in the basement.
- The basement also houses the raw sludge grinder and septage pump.

> HVAC Systems

In addition to the sludge heaters' exhaust stacks, the ground floor of the building has two exhaust fans on the wall for ventilation. Fresh air for the building is provided by cutouts on the wall, although plant operators typically keep the building door open. Heating for the ground floor is supplied by two Trane hot water heaters on the ceiling controlled by an on-off switch on the wall. The building has no mechanical cooling.

The basement is open to the ground floor via pipe risers on three of the side walls (one side is used for stairways). The basement does not have a heating or ventilation unit. It relies on heating and ventilation from the ground floor and Gallery J, which runs from the basement of Digester Control Building Number Four (No. 4) to this basement, and ends at Gallery B behind the Cogeneration Building.

> Lighting Systems

Interior lighting for the ground floor consists of 4 foot fluorescent light fixtures on the ceiling. Each fixture has two 32 W T8 lamps with vapor tight wrap controlled by occupancy sensors on the wall. The basement has the same interior lighting with 32 W T8 lamps and occupancy sensors. Two wallpack fixtures with HPS lamps provide exterior lighting.

2.3.13 Digester Control Building No. 4

> Building Description

Digester Control Building No. 4 is a one-story concrete building with a basement located next the Solids Dewatering Building. The main part of the ground floor is occupied by two sludge heat exchangers (HEX40201 and HEX40211). The building also houses three constant-speed 15 HP hot water pumps (P40202, P40212, and P40222). Pumps P40202 and P40212 were on, while pump P40222 was off during the walkthrough.

Sludge heat exchangers numbers one and two at Digester Control Building No. 4.

Electrical and storage rooms are located at the back of the ground floor. The electrical room houses the MCC cabinets and the control panels for the pumps and other equipment in the building. The storage room next door houses AHU 40111 for the electrical room and two vertical inline hot water 1 HP pumps (P40121 and P40122).

The equipment housed in the basement includes:

- Two 25 HP Vaughan sludge recirculation pumps (Nos. 1 and 2) with VFDs
- Two 40 HP constant speed digester sludge pumps
- One 40 HP sludge mixing pump with VFD
- Two sump pumps to pump out sump waste from wells below the basement.

> HVAC Systems

The electrical room on the ground floor is served by AHU 40111 located in the storage room next door. It is a cooling-only unit with split DX coil and a 5-ton York condensing unit outside. Outside air is ducted to the AHU through the wall, and return air is provided through the storage room. Exhaust fan EF40103 on the roof provides exhaust for the electrical room.

Located on the roof, AHU 40101 is a 100 percent outside air unit that supplies fresh air to the building. The unit has hot water coils for heating and no mechanical cooling. The outside air supply for the AHU is ducted to both the ground floor and basement below. There is no return or exhaust air provision at the AHU. Exhaust for the building is through the electrical room on the ground floor via EF40103.

> Lighting Systems

The building has windows for natural light. The main room on the ground floor has six high-bay fixtures with metal halide lamps. The electrical and storage rooms on the ground floor have 4 foot fluorescent light fixtures, each with two 32 W T8 lamps. The basement has the same fluorescent lamps as the electrical and storage rooms. All fluorescent light fixtures in the building are controlled by occupancy sensors with timers on the walls. Four wallpack fixtures with HPS lamps provide exterior lighting.

2.3.14 Electrical Equipment Building

> Building Description

The Electrical Equipment Building is a one-story concrete building located south of the Headworks Building. The building is used as the primary electrical room for the plant. The interior of the building is divided into two rooms. Both the front and back rooms house the high voltage electrical cabinets and distribution systems from the utility to the rest of the treatment plant. Two high voltage transformers are installed on the ground at the back of the building. These utility transformers service the two main electrical feeds to the plant.

Electrical Equipment Building

> HVAC Systems

There is no heating or cooling systems for the building. Ventilation for the front room is provided by a wall-mounted exhaust fan that runs continuously. Ventilation for the back room is provided by an exhaust fan on the roof.

> Lighting Systems

The front room of the building has windows for natural light, while the back room has skylights. Additional lighting is provided by 4 foot fluorescent light fixtures with vapor tight wraps. They are all two lamp fixtures with 32 W T8 lamps and electronic ballasts.

2.3.15 Ferric Chloride Building

> Building Description

The Ferric Chloride Building is a one-story concrete building next to the Solids Dewatering Building. The building houses the ferric chloride pumps that feed chemicals to the digester tanks outside the building.

The building houses five 0.5 HP feed pumps with VFD control to serve each of the five digester tanks. There is also a ferric chloride tank for day storage and use inside of the building. The main storage tank for the chemical is outside in an enclosed container. There is also a 1.5 HP sump pump in the building for spillover chemical clean-up.

Ferric Chloride Building

> HVAC Systems

Fresh air is supplied by one AHU mounted on the ceiling. It is a 100 percent outside air unit with a hot water coil for heating. The unit has no cooling capability. There is a three-way hot water valve for control tied to a wall-mounted thermostat. Ventilation is provided by one exhaust fan on the wall. Additional heating for the building is provided by a Dayton unit heater mounted on the ceiling.

> Lighting Systems

Interior lighting for the building is comprised of 4 foot vapor-tight fluorescent light fixtures. Each fixture has two 32 W T8 lamps with electronic ballasts. All interior light fixtures are controlled by occupancy sensors on the wall. One wallpack fixture with a HPS lamp is located above the entrance door outside for exterior lighting.

2.3.16 Filter Facility

Filter facility for post-aeration effluent

> Building Description

The Filter Facility refers primarily to the surface concrete basins used for post-aeration filtration. There are a total of twelve filter banks and a one-story concrete building with observation posts along the middle of the basins. In addition to the observation posts, the building has an office and electrical room housing the MCC cabinets for the filter equipment. There is a large underground gallery that houses the filter equipment beneath the basins. Two 60 HP spent wash pumps and two 200 HP filter backwash pumps are located in the gallery. Air for the filter backwash pumps is supplied from the backwash blowers in the Chemical Building's basement. During the walkthrough, one spent backwash pump was running, but both filter backwash pumps were off.

Control valves for the spent wash and backwash operations are located on an interstitial mezzanine above the filter gallery. The floor of the mezzanine is made from corrugated steel plates.

There are two 40 HP pumps located on one end of the filter banks. These are equalization basin pumps used to divert water from the filter banks to the equalization basin beside it for overflow control. During the walkthrough, the pumps were not running and the equalization basin was empty.

> HVAC Systems

Ventilation for the underground filter gallery and mezzanine is provided by two McQuay AHUs located on the mezzanine, one for supply air and one for exhaust. The supply AHU is a 100 percent outside air unit with hot water coils for conditioning. Fresh air is ducted from the surface above to the unit, tempered, and then ducted to the filter gallery below. Hot water flow to the supply AHU is controlled by a wall thermostat in the mezzanine. The exhaust AHU vents the air from the underground chamber to the surface above via the mezzanine. Both units run continuously.

The observation hallway in the surface building has two wall-mounted dome fans for exhaust. Heating for the hallway is provided by two Trane unit heaters with hot water coils. The heaters have two-way hot water valves for control and are regulated by wall-mounted manual thermostats. The office at the end of the surface building has a hot water baseboard heater along the wall and a Comfort Aire window air conditioning (A/C) unit for cooling and fresh air supply.

Heating, cooling, and ventilation for the electrical room is provided by a Trane packaged AHU outside the building. Supply- and return-air from the room is ducted to the packaged unit outside. Exhaust and outside air intake occur at the AHU, as well. The AHU has a packaged DX system for cooling and a 480 volt (V) electric heater for heat.

> Lighting Systems

The underground filter gallery has a total of nineteen light fixtures. They are all 4 foot pendant-type hanging fixtures, each with two 32 W T8 fluorescent lamps. Lights in the gallery are controlled by automatic occupancy sensor on the walls. The mezzanine floor has 32 W T8 fluorescent light fixtures with occupancy sensors on the walls.

The observation hallway has skylights and windows for natural light. In addition, it has 4 foot wrapped fixtures on the ceiling with two 32 W T8 lamps each. These fixtures are controlled by occupancy sensors on the walls. The MCC room and office have the same light fixtures as the hallway. Lights in the MCC room have occupancy sensors, but those in the office do not.

Exterior lighting around the building and the concrete banks are wallpack fixtures with HPS lamps. Above the filter banks, there are pole-mounted shoebox fixtures with HPS lamps.

2.3.17 Galleries A – K

> Building Description

The treatment plant is occupied mainly by the process tanks and basins, with the supporting buildings surrounding the tanks. Around the perimeter of these tanks and buildings, are underground tunnels and surface galleries that interconnect the facilities. The underground tunnels are used mostly as pipe galleries for wastewater and sludge transfer between tanks and basins, although they also house process pumps. The surface-level galleries are similarly used for pipe galleries; many electrical distribution cabinets are located in these galleries, as well.

RAS pumps 1 C-1 and 1 C-2 in Gallery A.

Gallery A

Gallery A is an underground tunnel that runs east-west along the southern end of the secondary sedimentation tanks. It starts from Gallery B at the Blower Building and ends at the Return Activated Sludge (RAS) Pump Building.

The gallery houses the following equipment:

- Two RAS pumps for each of the six original secondary sedimentation tanks, for a total of twelve pumps. All of the pumps are 30 HP with VFDs at their electrical cabinets.
- Two RAS pumps for the newest secondary sedimentation tanks from the 2007 expansion are located in the RAS Pump Building.
- Four HACH controllers for the dissolved oxygen (DO) sensors in the aeration basins. Each of the four controllers monitors three DO levels in the basins.
- Two unused 60 HP phosphorous precipitate pumps. These pumps were originally used for phosphor removal at the PhoStrip tanks, but the process was changed in the 2007 expansion and these two pumps were abandoned in place.

Gallery B

Gallery B is a surface-level tunnel that runs north-south from the Administration Building to the Grit Building. The gallery is used mainly as a pipe gallery, but the sludge and scum pumps for Primary Sedimentation Tank 1A are located in Gallery B near the Grit Building. Both the sludge and scum pumps are 15 HP pumps with VFDs at the electrical cabinets.

Gallery C

Gallery C is surface-level tunnel that runs east-west along the southern end of the six original primary sedimentation tanks. The gallery houses the sludge and scum pumps for five of the tanks. The sludge and scum pump for tank 1A are located in Gallery B (as described above). The sludge and scum pumps for tanks 1B, 1C, 2A, 2B, and 2C are identical. They are all 15 HP pumps with VFDs near the pumps. The sludge and scum pumps for the newest primary sedimentation tank from the 2007 expansion are located in the DAFT Building.

Gallery C with the row of sludge and scum pumps for the primary sedimentation tanks.

In addition to these pumps, Gallery C houses two thickened primary sludge (TPS) pumps. These TPS pumps are used to transfer thickened sludge from the Gravity Thickeners Facility to the acid digester. They are 20 HP pumps with VFDs. There are also two #3 water pumps next to the TPS pumps to transfer separated wastewater from the Gravity Thickeners Facility back to the main process stream. These #3 water pumps are 15 HP pumps with no VFDs.

Gallery D

Gallery D is an underground tunnel used primarily for pipe runs between the Cogen Building and Digester Building No. 3. There is no equipment in the gallery. A digester gas pipe from the methane digester tanks to the flare and then to the Cogen engine runs in this gallery. There are also pipes in the gallery for centrate and #2 water.

Gallery E

Gallery E is a north-south underground tunnel that starts from Gallery C near primary sedimentation tank 1C and ends at Gallery A. There is no equipment in the gallery aside from pipe chases overhead. A small section of the gallery is used for document storage.

Gallery F

Gallery F runs from where Gallery E ends in Gallery A and continues north to the outside door between the Laboratory Building and the post-aeration tank. There is no equipment in the gallery except for the two 25 HP jet post-aeration pumps with VFDs at the end of the gallery. During the walkthrough, one of the pumps was disassembled.

Gallery G

Gallery G is an underground tunnel that runs north-south from secondary sedimentation tank 2C to Gallery A. Gallery G houses six anaerobic RAS (ARAS) pumps that transfers ARAS from the secondary sedimentation tanks to the DAFT Building for thickening. Anaerobic RAS is also known as waste activated sludge (WAS). ARAS pumps 1A-1, 1A-2, 1B-1, 1B-2, 2B-1, and 2B-2 in Gallery G are all 30 HP-pumps with no VFDs.

Gallery H

Gallery H runs from where Gallery G ends in Gallery A and continues south to the DAFT Building. There are two more ARAS pumps in Gallery H. ARAS pumps 2A-1 and 2A-2 in this gallery are the same as the ARAS pumps in Gallery G (30 HP pumps with no VFDs).

Gallery I

There is no Gallery I in the treatment plant.

Gallery J

Gallery J is an underground tunnel used as a pipe gallery between Digester Control Building No. 3 and Digester Control Building No. 1 near the plant's main entrance. Pipes that run in this gallery include those for digester gas, thickened primary sludge, thickened WAS, and digester sludge. There is no process equipment in the gallery.

Gallery K

Gallery K is a surface-level tunnel that connects Gallery H at the DAFT Building to Gallery C. There is no process equipment in the gallery.

> HVAC Systems

All of the galleries are connected, and therefore share heating and ventilation systems. HVAC systems located within the galleries are as follows:

- Make-up air for the galleries is primarily supplied through Gallery B by one Torrivent Trane AHU located in the Blower Building. It is a 100 percent outside air unit with a hot water coil for heating. Hot water flow to the AHU is controlled by a wall-mounted thermostat in Gallery B.
- Gallery C has one exhaust fan on the wall for ventilation and a Dayton hot water unit heater on the ceiling for heating.
- Gallery F has one exhaust fan on a wall near the exit door.
- Gallery K has one exhaust fan on the wall for ventilation, and a Trane hot water unit heater for heating.
- No other heating or ventilation equipment was seen in the galleries.

In addition to these units, the galleries share the heating and ventilation system of the buildings to which they are connected. These include the heating and ventilation systems at the Grit Removal Building, DAFT Building, RAS Pump Building, Digester Control Buildings, and others.

> Lighting Systems

Interior lighting for the galleries is primarily provided by 4 foot vapor-tight or wrapped fluorescent light fixtures in the galleries. Each fixture has two 32 W T8 fluorescent lamps with electronic ballasts. These fixtures are typically controlled by wall-mounted occupancy sensors.

2.3.18 Grit Removal Building

> Building Description

The Grit Removal Building is a two-story concrete structure next to the Cogen Building that is used for separating grit, sand, and other sediment from the influent wastewater. Two large grit tanks outside the building hold the wastewater for treatment. Two 20 HP grit pumps on the ground floor of the building pump the water to the two grit separator machines on the second floor. Separated grit from the machines is collected in a trash chute and is disposed in a 14 yard trash bin underneath the chute.

Grit separators in the Grit Removal Building

Two large rollup doors provide access for the building. They are normally left open to accommodate the length of the grit trash bin. There is a warehouse and shop area located at the back of the building on the ground floor that was predominantly empty during the walkthrough. The building is also the intersection point for Galleries B and C.

> HVAC Systems

There is no dedicated make-up air unit for the building because it is typically open to the outside. However, there is a wall-mounted exhaust fan on the second floor that runs continuously. Heating for the ground floor is provided by two Dayton unit heaters on the ceiling. They are both hot water unit heaters controlled by a wall-mounted on/off switch. There was no heating equipment identified on the second floor. There are two 20 HP hot water pumps without VFDs in Gallery C near the heaters that provide the units with hot water. During the walkthrough, one pump was off while the other pump was running on “hand” mode.

> Lighting Systems

There are numerous 4 foot vapor-tight fluorescent light fixtures providing interior illumination for both the ground and second floors of the building. Each fixture has two 32 W T8 fluorescent lamps with electronic ballasts. These fixtures are controlled by wall-mounted occupancy sensors.

Exterior lighting for the building is provided HPS lamps housed in eight wallpack fixtures.

2.3.19 Headworks Building

> Building Description

The Headworks Building is a one-story concrete structure with a basement located adjacent to the Administration Building. Two wet wells for raw sewage influent are located outside the building. Primary screening for the influent wastewater is conducted by two 3 HP underground bar screens. There are four vertical turbine raw sewage pumps inside the building which transfer the raw sewage from the wet wells to the grit removal facility for further treatment. These raw sewage pumps are Titan series with 500 HP motors, all with VFDs. During the walkthrough, two pumps were running at 48 Hz. On one side of the Headworks Building is an AFD room that houses the high voltage electrical cabinets for the raw sewage pumps.

A wet well pressure washer system is located in the building in addition to the raw sewage pumps. The system includes three compressed air units and an air holding tank. Electrical cabinets for these and other equipment are located along the wall in the main room.


Raw sewage pumps at the Headworks Building. Pump motors (left); Pump shaft to wet well below (right).

> HVAC Systems

Ventilation for the two influent wet wells is provided by one supply and one exhaust fan installed on the ground above the wells. Exhaust air from the wells is ducted to an outdoor odor scrubber tank before it is released to the atmosphere.

Ventilation for the main pump room is provided by one PACE make-up AHU on the roof and one exhaust fan in the room. The make-up air unit is a 100 percent outside air unit with an evaporative cooler for cooling. There is no heating coil on the AHU. Fresh air from the unit is ducted from the roof to the inside the building and basement level. Exhaust is ducted from the basement to outside via a wall penetration. Heating for the building is supplied by two Dayton and one Reznor hot water heaters.

Two Carrier packaged AHUs located outside of the building provide mechanical cooling to the AFD electrical room. The packaged units have DX refrigerant system for cooling, but no heating capability. Supply and return air to and from the AHUs are ducted through the wall from the AFD room.

During FGOA, plant operations informed Ameresco that the PACE make-up AHU and the two Carrier packaged AHUs will be replaced because they are at the end of their service lives. The make-up AHU will be replaced with a similar unit with an evaporative cooler. The two Carrier packaged AHUs, however, will be demolished. They will be replaced with four fan coil units with split DX systems installed inside the AFD room. Condensing units for the new fan coil units will be installed on the roof.

> Lighting Systems

The building interior is illuminated by ceiling-mounted and wall-mounted HPS light fixtures. The AFD room too has HPS lamps for interior lighting. Exterior of the building has two HPS light fixtures and four wallpack fixtures with hardwired CFL lamps for lighting.

2.3.20 Laboratory Building

> Building Description

The Laboratory Building is a two-story concrete building located along the north side of the secondary sedimentation tanks. Originally constructed in 1997, the building was renovated in 2003 with the addition of new laboratories, offices, and HVAC equipment. The building is used as a laboratory facility for sampling and testing water quality from the treatment process. The first floor of the building is used for laboratories, offices, locker rooms, a mechanical/electrical room, and a storage room. The second floor of the building is used for laboratories and offices only. Offices typically have 9 foot ceilings with carpeted floors, while laboratories typically have higher, 12 foot ceilings with linoleum floors. Interior partitions in the building are primarily gypsum dry walls.

Typical laboratory/office in the Laboratory Building

There are numerous pieces of laboratory equipment in the building, including refrigerators and freezers to store water and solid samples, table-top centrifuges, fume hoods, ovens, ice machines, incubators, and other pieces of equipment. The offices have computers, phones, and other typical office equipment.

> HVAC Systems

Primary HVAC system for the building is provided by one packaged AHU located on the roof that serves the entire second floor, in addition to the office and laboratories on the eastside of the first floor. The AHU is a single-duct unit with supply and return fans, DX coil for cooling, and a hot water coil for preheat.

A Trane condensing unit for the DX coil rated at 42-tons of total cooling is located on the roof. Supply and return air from and to the AHU is ducted below through a roof penetration. Outside air is taken from one side of the AHU, while exhaust air is vented from the other side. There is a honeycomb plate-frame heat exchanger inside the AHU for heat recovery between the two air streams. There are six ducted Temtrol hot water heaters in the rooms for the packaged AHU used for individual comfort control at the room levels. Hot water flow for the heaters is regulated by Staefa mixing valves controlled by wall-mounted thermostats on the walls.

In addition to the ventilation provided through the packaged AHU, fume hoods in the laboratories provide direct exhaust to the roof. There are also one dedicated exhaust fan on the roof and two exhaust fans on the side walls for additional ventilation for the second floor laboratories.

In addition to the packaged AHU, the solids laboratory on the second floor has a Trane 2-ton DX packaged RTU for additional cooling. The unit has no heat option.

Offices, laboratories, and sample rooms on the first floor not served by the packaged AHU have hot water unit heaters on the ceiling. They are typically Dayton unit heaters with wall thermostats for control. Some of the rooms also have Frigidaire wall A/C units for cooling. Ventilation for these rooms is provided by exhaust fans that vent directly to outside. The men's and women's restrooms also have a general exhaust fan each on the wall for ventilation.

> Lighting Systems

Typical interior lighting fixtures for the building are 4 foot fluorescent fixtures with vapor tight wraps. The fixtures are a combination of two- or three-lamp configurations with 32 W T8 fluorescent lamps and electronic ballasts. Some of the rooms on the first floor have T12 fluorescent lamps and magnetic ballasts in the fixtures.

Night lighting is provided by wallpack fixtures on the exterior walls of the building. The majority are 50 W HPS fixtures; some fixtures have 23 W compact fluorescent lamps.

There are wallpack fixtures on the exterior walls of the building for night lighting. They are typically 50 W High Pressure Sodium fixtures, although there are a few fixtures that have 23 W compact fluorescent lamps (CFL).

2.3.21 Maintenance/Warehouse Building

> Building Description

The Maintenance/Warehouse Building is a relatively new building located at the north side of the treatment plant. It is a steel frame building with metal siding on the interior and exterior. The walls and ceilings are insulated. Ceiling insulation is cut away in some places for daylighting. The building has a pitched sheet metal roof with some mechanical equipment on it accessible via a ladder on the side of the building.

Maintenance/Warehouse Building

The building consists of three main parts: a warehouse section on the west side of the building, a shop section on the east side, and an office section in the middle. The three sections are open to each other without a partition. There are large rollup doors in the warehouse and shop sections for large equipment access. The north end of the building is a fenced outdoor storage area, while the east end of the building is used as an outdoor welding area.

The warehouse section provides the primary storage space for the treatment plant. There are steel racks used to store spare parts and miscellaneous equipment. The main area of the shop section is used for general maintenance activities, as well as a parking garage for the plant's golf-carts after the day shift. The shop has a dedicated welding/machine and electrical shop on the north side. There is a mezzanine above these shops where TMWRF stores the as-built drawings for the plant. The office is a two-story facility with individual offices on the ground and second floors, as well as break and locker rooms on the second floor.

> HVAC Systems

Warehouse

Ventilation for the warehouse is provided by three exhaust fans on the ceiling. Fresh air is provided by three wall grilles located around the warehouse. Heating for the main warehouse space is supplied by five Reznor ceiling-hung unit heaters. These heaters have propane gas burners with blowers controlled by a thermostat mounted on the units. In addition, there are two Reznor and one Modine propane heaters for the staging area near the offices. The warehouse section has no mechanical cooling.

Shop

Similar to the Warehouse section, ventilation for the shop is provided by three exhaust fans on the ceiling with wall grilles for fresh air intake. There are two Reznor propane heaters in the main area and two additional Reznor units on the mezzanine for heating. The welding/machine room has a dedicated fan that exhausts directly outdoors. The room also has two Reznor heaters with propane burners. The entire shop section has no mechanical cooling; however, the electrical shop is conditioned by the AHU serving the office area.

Offices

Heating, ventilation, and air conditioning for the ground and second floors of the office area are provided by one PACE AHU in the mechanical room at the back of the offices. The AHU is a single-duct variable air volume (VAV) unit with a supply fan, exhaust fan, DX cooling coil, and hot water heating coil. There are VFDs on the supply and exhaust fans for flow control. Supply and return air from the AHU is ducted to and from the rooms through the plenum. Exhaust and outside air intake are ducted from the AHU to the outside wall.

Cooling for the AHU is provided by an outdoor Trane 10-ton condensing unit with two refrigerant circuits. Heating for the AHU is provided by one Ajax boiler in the mechanical room. The boiler has a propane burner rated at 250-MBH input and 200-MBH output (80 percent efficiency). There is an inline 0.75 HP hot water pump for circulation between the boiler and the AHU. The mechanical room also has a 40-gallon capacity Bradford White electric heater for domestic hot water use.

Propane gas for the Maintenance/Warehouse Building and Training Building is supplied by two over-ground propane tanks outside the building. Each tank provides 1,075-gallons of liquid storage with on-site propane vaporizers.

> Lighting Systems

Main areas of the warehouse and shop have high bay light fixtures with metal halide lamps, while the offices and other areas of the building have fluorescent light fixtures. Fixtures for the offices, restrooms, hallways, and other general area are a combination of 4 foot, two-lamp, 32 W T8 fixtures and 2 foot, two-lamp biax fluorescent lamps with troffers.

The building’s exterior has a total of nine wall-mounted light fixtures with HPS lamps.

2.3.22 Methanol Facility

> Building Description

The Methanol Facility is comprised of a small, 500 SF, one-story building and three methanol storage tanks located between the nitrification towers and equalization basin. The three storage tanks provide a continuous methanol supply to the Denitrification Facility for ammonia removal. Four 1.5 HP feed pumps with VFD control for the methanol transfer are located inside the building. During the walkthrough, feed pumps Nos. 1 and 2 were running at 25 Hz, while pumps Nos. 3 and 4 were off.

Methanol tanks

> HVAC Systems

Ventilation for the building is provided by two exhaust fans on the roof. Fresh air supply is taken from grilles on the wall. Heat for the building is provided by four vertical cabinet hot water heaters along the walls.

> Lighting Systems

There are no windows on the building. The building interior is lighted by six CFLs mounted on the ceiling. The lamps are encased in explosion proof fixtures and are hardwired to the electrical system.

2.3.23 Nitrification Pump Station

> Building Description

The Nitrification Pump Station is a two-story concrete structure. The original construction date is unknown, but estimated to be in the mid-1960s. The facility operates 24 hours per day throughout the year. The first floor of the building houses the electrical switchgear and the equipment's MCC. A Westinghouse capacitor bank is located on the first floor for power factor correction.

Influent and effluent pumps at the Nitrification Pump Station.

The second floor houses four 200 HP influent pumps for the nitrification towers and four 400 HP pumps to transfer effluent from the nitrification towers to the Denitrification Facility. The influent and effluent pumps are variable speed and have vertical-turbine configurations. The VFDs are located on the second floor next to the pumps. During the FGOA, plant operations informed Ameresco that all VFDs are scheduled to be replaced. As of August 2013, one drive had been replaced and three replacement drives had been ordered. Replacement drives for the remaining four pumps are in the planning stages.

The ammonia analyzer room is outside the pump room on the second floor. The room is mostly empty with only a few control panels lining the walls.

> HVAC Systems

Ventilation for the first floor is provided by exhaust fan EF75065 mounted on the wall. Heating for the first floor is provided by a ceiling-mounted Trane hot water unit with a two-way valve on the hot water pipe for temperature control. The valve is controlled by a wall-mounted manual thermostat. There is no mechanical cooling for the first floor.

Ventilation and cooling for the pump room on the second floor is provided by a rooftop AHU above the room. The AHU uses 100 percent outside air unit with an evaporative cooler. Supply air for the room is ducted from the AHU to the pump room. Room exhaust is provided by an exhaust fan on the roof. Heating for the pump room is supplied by two hot water unit heaters on the ceiling. Controls for the heaters are via dials on the wall with high/low/off options only.

The ammonia analyzer room has one through-wall exhaust fan (EF75068) for ventilation and one Trane hot water heater for heating. The unit heater is controlled by an on-off switch on the wall.

The room has no mechanical cooling. Exhaust fan EF75067 labeled as the exhaust fan for the room below is also located in the ammonia analyzer room.

> Lighting Systems

Light fixtures on the first floor of the building are 4 foot fluorescent fixtures with two 32 W T8 lamps and electronic ballasts. Light fixtures on the second floor are the same as the first floor, except they have industrial cage wire guards instead of vapor tight wraps. There are some HPS lamps in the stairwells in the building, as well as HPS wallpacks for the building’s exterior.

2.3.24 Nitrification Tower Recirculation Pump Station

> Building Description

Nitrification Tower Recirculation Pump Station

The Nitrification Tower Recirculation Pump Station is a small building located to the east of the nitrification towers. It is a steel frame structure with metal siding used as an electrical room for the recirculation pumps for the nitrification towers. There are two electrical cabinets inside of the building: One cabinet for recirculation pump P-X-1, and one cabinet for recirculation pump P-Y-1. The pumps are located underground outside the building. P-X-1 is constant speed. P-Y-1 is variable speed. The VFD for pump P-Y-1 is an Allen Bradley VFD located on the electrical cabinet. The pumps are used for snail control at the nitrification towers. Both pumps were in operation during the walkthrough.

> HVAC Systems

There is neither mechanical heating nor a ventilation unit for the building. It only has a grille on the wall for natural ventilation.

> Lighting Systems

The building's interior has three 4 foot light fixtures, each with two 32 W T8 lamps. There is no additional exterior lighting.

2.3.25 Primary Sludge Screening Building

> Building Description

The Primary Sludge Screening Building is a two-story concrete building next to the gravity thickener tanks. The facility is used to screen the sludge from the primary sedimentation tanks, which then travels to the gravity thickener tanks and then the acid digester. The two screening machines for the facility are located on the second floor of the building. The screening machines have 5 HP compactors for screened waste compaction. Screened waste from the machines is piped to the ground floor below for disposal to an open waste bin. A forklift is used regularly to empty the bin into a 30 yard waste compactor outside the building for final disposal to the landfill.

Sludge screener at the Primary Sludge Screening Building

Sludge from the screeners is pumped to the gravity thickener tanks by one gravity thickener (GT) scum pump on the ground floor. It is a 20 HP pump with a VFD at the electrical cabinet. The pump was running at 45 Hz during the walkthrough. An electrical room on the ground floor houses the electrical distribution cabinets for the equipment.

> HVAC Systems

AHU 28301 located on the ground floor supplies fresh air to both the ground and second floors of the building. The make-up air unit is a 100 percent outside air unit with a hot water coil for heating. The AHU does not have the capacity for mechanical cooling. Ventilation for the ground floor is provided by one exhaust fan on the wall. Ventilation for the second floor is also provided by one wall-mounted exhaust fan.

The electrical room on the ground floor has one AHU for ventilation and cooling. The AHU is a vertical cabinet unit with a split DX coil and a 3-ton York condensing unit outdoors. Supply and return air for the AHU is taken from the room; outside air is taken from a wall penetration next to the unit. Wall grilles provide room exhaust.

> Lighting Systems

Interior lighting for the ground and second floors of the building is provided by metal halide lamp fixtures with explosion-proof enclosures. The electrical room has the typical 4 foot fluorescent light fixtures with two 32 W T8 fluorescent lamps and electronic ballasts. The light fixtures in the electrical room are controlled by wall-mounted occupancy sensors.

2.3.26 RAS Pump Building

> Building Description

The RAS Pump Building is a two-story concrete building with a basement near the Chlorination Building. The basement of the building houses two RAS pumps for the newest secondary sedimentation tank. Both pumps are 30 HP with VFDs. During the walkthrough, one pump ran at 52 Hz. There is a unisex restroom at the corner of the basement with a toilet and a sink. The basement of the RAS Pump Building connects to Gallery A. The ground and second floors of the building are empty and unused.

> HVAC Systems

Ventilation for the basement is provided by EF-44104 mounted on the wall of the room. Outside air for the room is supplied by AHU-44101 mounted on the ceiling near the entrance door. The AHU is 100 percent outside air unit with a hot water coil for heating. The unit has no cooling capability. Hot water for the AHU is controlled by a wall-mounted thermostat. The restroom has a general exhaust fan on the wall.

> Lighting Systems

The basement has a 4 foot fluorescent light fixture for interior lighting. Each light fixture has two 32 W T8 fluorescent lamps with electronic ballasts. The fixtures are controlled by wall-mounted occupancy sensors.

2.3.27 Reuse Irrigation Pump Station

> Building Description

The Reuse Irrigation Pump Station is a pumping facility just south of the Maintenance/Warehouse Building. The facility houses the reuse pumps that supply the final effluent from the plant to the surrounding farms, instead of discharging it to Steamboat Creek. The main pump room is located underground. There are a total of five reuse pumps:

- Four 700 HP Titan II constant volume pumps with soft starters
- One 250 HP jockey pump with a VFD at the MCC

The reuse pumps are typically used during the summer months. One of the 700 HP pumps and the smaller 250 HP pump are typically used in the operation, although a second 700 HP pump is occasionally operated during periods of peak irrigation demand.

The MCCs and electrical cabinets for the pumps are located inside a small building above the underground pump room. It is a sheet metal container building used solely to house the electrical equipment.

Reuse irrigation pump station (left); Underground pump room (right)

> HVAC Systems

Ventilation for the underground pump room is provided by three Greenheck supply fans and three Greenheck exhaust fans on the surface above the room, all of which operate continuously. Heating for the underground pump room is provided by two Chromalox electric unit heaters on the ceiling. There is no mechanical cooling for the room.

The electric room (i.e., container building) has two exhaust fans on the roof. Fresh air is taken from a grille on the wall. The room has neither heating nor cooling equipment.

> Lighting Systems

Lighting for the underground pump room is provided by HPS light fixtures with explosion-proof enclosures. The electric equipment container has three fluorescent light fixtures with 32 W T8 lamps. Night lighting is provided by a wallpack light fixture with a 50 W HPS lamp located outside the building above the entrance door.

2.3.28 Screening Facility

> Building Description

The Screening Facility refers to the two Rex screening machines located in front of the Methanol Facility. The machines are travelling water screening systems that remove snail shells from the nitrification towers effluent. The machines are located outdoor on a concrete pad, and are not enclosed in a building. Both machines were off during the walkthrough.

> HVAC Systems

Not applicable (n/a).

> Lighting Systems

There is no exterior lighting at the Screening Facility.

2.3.29 Solids Dewatering Building

> Building Description

The Solids Dewatering Building is a three-story concrete structure near the methane digester tanks. It is a dewatering facility for the treatment process where digested sludge from the methane digesters is dewatered before final hauling to the landfill. Centrate water from the dewatering process is pumped back to the influent wet wells at the Headworks Building to restart the treatment cycle.

Solids Dewatering Building

The ground floor of the building houses various pumps for the sludge and polymer used in the dewatering process:

- Three V-RAM sludge-feed pumps for the centrifuges are located on the ground floor.
- Three 0.5 HP polymer pumps feed the polymer from a tank on the ground floor to the sludge during the dewatering process.
- 1.5 HP polymer transfer tank on the ground floor used to fill the polymer tank.
- Two 7.5 HP centrate pumps near the entrance door transfer centrate water from dewatering process back to the main treatment process. Both centrate pumps have VFDs installed in the electrical cabinets.

Sludge dewatering is performed by three horizontal bowl centrifuges located on the second floor. Each centrifuge has a 125 HP main drive motor and a 15 HP back drive motor. The dewatering process using these existing centrifuges produces approximately 15 percent solid content for the sludge cake. During the walkthrough, all three centrifuges were off.

Dewatering centrifuges

There is an office on the second floor for monitoring centrifuge operations. There are also two 10 HP number three water pumps on the second floor. Electrical cabinets for the centrifuges and pumps in the room are located on the wall on the second floor.

The solid cake storage hopper machines are located in the hopper room at the back of the second floor. There are four hopper machines which occupy this room and extend to the third floor above. The machines have screw conveyors to transfer the solid cake from the centrifuges to the storage hoppers. Directly underneath the hopper machines are two drive-through lanes where garbage trucks collect the solid cake for final disposal.

The third floor of the building is the odor control room where sludge gas produced in the dewatering process is burned in a boiler to generate hot water. The boiler has a Webster burner with a rated maximum capacity of 210 MBH. There is also a number two water storage tank in the room for the hot water system. Solid cake from the centrifuges is fed to the hopper machines through pipes housed in this room; the feeding system is controlled by open/close valves in the pipes.

> HVAC Systems

Fresh air supply for the ground floor is provided by one AHU hung on the ceiling. It is a 100 percent outside air unit with a hot water coil for heating; the unit has no cooling capability. The AHU has two booster pumps to supply hot water to the coil. There is no dedicated exhaust fan for the room. Additional heating for the ground floor is provided by two unit heaters on the ceiling. These units have axial fans with hot water coils.

Heating for the centrifuge room on the second floor is provided by three Dayton hot water heaters on the ceiling controlled by wall-mounted thermostats. Exhaust for the centrifuge room is provided by an exhaust fan on the roof. The office and restroom on the second floor has one small general exhaust fan on the roof for ventilation.

The odor control room has two axial exhaust fans on the walls for ventilation which continuously run. Speed control is provided by high/low switches on the fan frames. There is no heating equipment for the room aside from the boiler.

> Lighting Systems

The ground floor of the building has fluorescent light fixtures for interior lighting. These fixtures are 4 foot vapor tight fixtures, each with two 32 W T8 fluorescent lamps. The centrifuge room on the second floor has low, bay light fixtures with metal halide lamps for interior lighting. The centrifuge room also has skylights on the roof for natural daylight. The odor control room on the third floor has the same vapor tight fluorescent light fixtures as the ground floor.

Wallpack light fixtures with HPS lamps provide exterior lighting.

2.3.30 Storage Building

> Building Description

The Storage Building is a one-story building located between the Administration and Blower Buildings. Like the other buildings in the row, it is concrete with a stucco façade and glass-block windows near the ceiling. Three rollup doors provide access to the building. The building has approximately 2,000 SF of interior space used primarily for storing equipment and vehicles. There is no process equipment in the building.

> HVAC Systems

The building has no mechanical ventilation or cooling. Two hot water unit heaters hung on the ceiling in the corners provide building heating. Each unit has a two-way valve with Belimo actuators to control the hot water flow. The two valves are controlled by one non-programmable thermostat on the back wall of the building. The thermostat was set at 72° Fahrenheit (F) during the walkthrough.

> Lighting Systems

Interior lighting in the building consists of ceiling mounted fixtures with 200 W incandescent lamps. Exterior lighting consists of wallpack fixtures with HPS lamps above the rollup and entrance doors.

2.3.31 Training Building

> Building Description

The Training Building is a one-story prefabricated building located next to the Maintenance/Warehouse Building. It is approximately 1,500 SF with wood panel exterior and interior. It has a pitched roof and several windows, all of which are double-pane. The building is secured to a raised concrete platform.

The main room of the building is used as a training and conference room for TMWRF. It has a projector and computer, as well as tables and chairs. There is a kitchenette at one side of the building with a coffee maker, microwave oven, and other small kitchen appliances. There are two restrooms (men/women) in the building. There is a janitorial closet with a mop sink between the restrooms. The building is not usually occupied except during training and conference sessions.

> HVAC Systems

Heating, ventilation, and air conditioning for the building are provided by two Bard wallpack units on the exterior walls. The units each have one DX compressor and one propane gas furnace for cooling and heating, respectively. Supply and return air from building's interior is ducted to and from the units through the ceiling. Outside air for the building is taken directly at the units. The wallpack units are controlled by Honeywell, wall-mounted, programmable thermostats. During walkthrough, the thermostats were set to 70°F and 75°F heating and cooling setpoints, respectively.

The restrooms each have one general exhaust fan on the roof.

> Lighting Systems

Interior lighting for the building is primarily provided by 4 foot wrapped fluorescent light fixtures mounted on the ceiling. The fixtures have two 32 W T12 lamps with magnetic ballasts. Exterior lighting is provided by two wallpack light fixtures, each of which has one 70 W HPS lamp.

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3.0 Baseline Utility Use

3.1 Electricity

NV Energy provides electricity service to TMWRF. There are three electric meters at TMWRF as follows, and shown in Table 3.1.

- **Electric meter 260437** is the primary meter for the treatment process located at the Electrical Equipment Building. This service provides electricity to all process-related equipment and buildings in the plant.
- **Electric meter 465539** is located at the outdoor electrical cabinet near the Reuse Pump Station. Electricity from this meter provides power to the four 700 HP reuse pumps in the Reuse Pump Station.
- **Electric meter 149850** is located next to meter 465539. It serves the small 250 HP jockey pump at the Reuse Pump Station, as well as the Maintenance/Warehouse and Training Building on the north side of the property.

Table 3.1. Electricity Meters at TMWRF

Account/Premise Number	Service Rate	Service
939286-260437[1]	Large General Service (GS-3)	Primary electric meter. Serves all process-related equipment and buildings.
102938-465539	Large General Service (GS-3)	Serves the large pumps at the Reuse Pump Station.
102938-149850	Medium General Service (GS-2)	Serves the small jockey pump at the Reuse Pump Station, Warehouse/ Maintenance Building, and Training Building.

Notes:
1. The service has two redundant feeds that are billed as one service.

3.1.1 Large General Service (GS-3)

Electricity service for meters 260437 and 465539 are charged under rate schedule Large General Service Rate (GS-3) at primary voltage. This service is applicable to all services where monthly metered maximum demand during any period is equal to or greater than 1,000 kW. The rate schedule is a time of use (TOU) rate with summer and winter schedules. Both the summer and winter rates include an off-peak, mid-peak, and on-peak component. Table 3.2 shows the time-of-use periods and rates for GS-3.

Table 3.2. Time of Use Periods and Rates for GS-3 Schedule

Rate Schedule	Hours	Rate ($/kW)	Rate ($/kWh)
Summer Period (July through September)			
On-Peak	1:01 PM - 6:00 PM (weekdays)	7.40	0.11220
Mid-Peak	10:01 AM - 1:00 PM, 6:01 PM - 9:00 PM (weekdays)	3.05	0.08378
Off-Peak	All other hours	0.00	0.05749
Winter Period (October – June)			
On-Peak	5:01 PM - 9:00 PM (daily)	1.70	0.06638
Mid-Peak	7:01 AM - 5:00 PM (daily)	1.59	0.06095
Off-Peak	All other hours	0.00	0.04897

The peak kW demand is calculated based on the maximum measured 15 minute average kW load during the billing period. Demand charges for the service are calculated individually for the on- and mid-peak periods, and they are summed for total peak demand charge. The consumption kWh charge shown in Table 3.2 is the total charges for kWh usage including base tariffs, universal energy charge and others.

In addition to the kW and kWh charges in Table 3.2, the schedule also has a basic service charge of $370 per month, and a facilities demand charge. The facilities demand charge is calculated based on the maximum kW demand over the period, and is $7.11 per that maximum kW.

Table 3.3. Additional Charges for GS-3 Schedule

Rate Schedule	Cost ($)
Basic Service Charge (per month)	370
Facilities Charge (per kW of maximum demand)	7.11

3.1.2 Medium General Service (GS-2)

Electricity service for meter 149850 is charged under rate schedule Medium General Service Rate (GS-2) at primary voltage. This service is applicable to all services where monthly metered maximum demand during any period is greater than 50 kW and less than 500 kW. The rate schedule does not have time-of-use charges. Instead, consumption charge is consistent throughout the year. In addition to the consumption charge, the rate has a demand charge, facilities charge, and basic service charge. The demand charge is calculated based on the maximum measured 15 minute average kW load in the billing period. Table 3.4 lists the applicable charges included in rate GS-2.

Table 3.4. Rates for GS-2 Schedule

Rate Schedule	Cost ($)
Basic Service Charge (per month)	16
Consumption Charge (per kWh, all usage)	0.06754
Demand Charge (per kW, all kW)	3.33
Facilities Charge (per kW of max demand)	6.68

3.1.3 Electricity Consumption

The annual kWh consumption at the plant from January 2009 to September 2012 is shown in Table 3.5. Because electricity consumption at the plant depends on the amount of the wastewater treated, the normalized electricity consumption per millions of gallons (MG) of wastewater treated is also included. Both the raw annual electricity consumption and the normalized consumption metrics show an increasing electricity use trend.

The most recent 12 months of electricity use at the plant has been considered as the plant's baseline consumption because of the upward consumption trend over the past three years. Using this criterion, the baseline electricity consumption at the plant is 30.8 million kWh annually or 2,961 kWh per million gallon of wastewater treated.

Table 3.5. Annual Electricity Consumption

Meter	2009 (kWh)	2010 (kWh)	2011 (kWh)	2012[1] (kWh)	Baseline[2] (kWh)
939286-260437	23,009,374	25,504,842	27,782,188	20,876,998	28,078,205
102938-465539	1,983,588	2,076,428	1,856,830	1,947,390	2,210,600
102938-149850	453,623	336,800	490,296	373,390	531,785
Total (kWh)	**25,446,585**	**27,918,070**	**30,129,314**	**23,197,778**	**30,820,590**
Annual Average Influent Flow (MGD)	26.9	28.6	28.8	29.1	29.1
Days per Year	365	365	365	274	365
Total (kWh/mG Treated)	**2,592**	**2,674**	**2,866**	**2,909**	**2,961**

Notes:

1. Thru September 2012
2. Last 12 months (2012/2013)

3.1.4 Peak Electricity Demand

Table 3.6, Table 3.7, and Table 3.8 list the monthly kW demand of the three electric meters from January 2009 to September 2012. For meters 260437 (Table 3.6) and 465539 (Table 3.7), the monthly kW demands shown are the largest peak kW consumption from the off-peak, mid-peak, and on-peak periods. Electric meter 149850 is under GS-2 rate, and does not have time-of-use peak demand.

The main electric meter (260437) shows an increasing kW demand year-after-year for all months. This is partly due to the increase in the influent flow to the plant. Monthly kW demand is generally stable with only a slight change from month to month. The peak kW demand for 2011 was 3,893 kW recorded in November 2011. The monthly demand for the most recent 12 months has been considered the baseline.

Table 3.6. Monthly Peak kW Demand, Meter 260437

Month	2009 (kW)	2010 (kW)	2011 (kW)	2012 (kW)	Baseline (kW)
January	2,731	3,071	3,586	3,701	3,701
February	2,704	2,909	3,438	3,813	3,813
March	2,795	2,707	3,441	3,514	3,514
April	2,761	2,841	3,658	3,432	3,432
May	2,878	2,707	3,597	3,546	3,546
June	2,761	3,093	3,789	3,658	3,658
July	2,613	2,990	3,791	3,625	3,625
August	3,359	3,542	3,612	3,737	3,737
September	2,924	3,695	3,853	3,817	3,817
October	2,742	3,573	3,868		3,868
November	2,888	3,627	3,893		3,893
December	2,917	3,474	3,710		3,710
Maximum (kW)	**3,359**	**3,695**	**3,893**	**3,817**	**3,893**

Peak kW demand for meter 465539 that serves the large reuse pumps are relatively stable from year to year. The monthly demand profile at the meter shows the usage pattern of the pumps. The load is near zero during the winter when the pumps are not in use. Two 700 HP pumps are used in the summer, resulting in 1,100 kW of demand. When TMWRF only uses one pump, the kW demand is 550 kW. The monthly demand for the most recent 12 months has been considered the baseline.

Table 3.7. Monthly Peak kW Demand, Meter 465539

Month	2009 (kW)	2010 (kW)	2011 (kW)	2012 (kW)	Baseline (kW)
January	846	1,112	8	8	8
February	558	1,113	8	8	8
March	948	548	95	8	8
April	546	549	543	569	569
May	1,097	736	1,064	1,069	1,069
June	1,099	1,095	1,084	1,066	1,066
July	1,109	1,104	1,084	1,051	1,051
August	1,101	1,101	1,260	1,072	1,072
September	1,103	1,088	1,091	1,123	1,123
October	1,101	1,074	1,095		1,095
November	549	1,110	558		558
December	550	8	535		535
Maximum (kW)	**1,109**	**1,113**	**1,260**	**1,123**	**1,123**

Peak kW demand for meter 149850 is primarily due to the 250 HP small reuse irrigation pump. Using the pump at any time contributes approximately 100 kW to the monthly demand. The rest of the electricity demand for the Maintenance/Warehouse and Training Buildings is relatively stable at approximately 70 kW to 100 kW per month. The monthly demand for the most recent 12 months has been considered the baseline.

Table 3.8. Monthly Peak kW Demand, Meter 149850

Month	2009 (kW)	2010 (kW)	2011 (kW)	2012 (kW)	Baseline (kW)
January	79	77	198	171	171
February	82	72	195	161	161
March	114	64	218	224	224
April	73	54	194	206	206
May	68	51	199	202	202
June	70	58	67	63	63
July	108	53	70	68	68
August	75	179	69	209	209
September	80	50	72	73	73
October	111	49	76	78	78
November	74	188	202		202
December	77	194	199		199
Maximum (kW)	**114**	**194**	**218**	**224**	**224**

3.1.5 Electricity Cost

The total annual electricity costs from January 2009 to September 2012 are shown in Table 3.9. Please note the costs shown for meter 260437 do not include the reduced costs from biogas electricity generation for fair comparison between the years 2009, 2010, 2011, and 2012. TMWRF operated the on-site biogas cogeneration engine from 2005 until it was decommissioned in July 2010. The costs shown are the total charges for meter 260437 before the deductions for the biogas electricity generated at the facility.

To better understand the base electricity costs for plant operations, the total annual costs are normalized by the annual volume of wastewater treated at the plant. The normalized cost index shows that the electricity cost for the treatment process has been relatively stable at around $237 per million gallons of wastewater. There was a decrease in the normalized electricity cost in 2010; however, it was still within the normal random variation.

Table 3.9. Electricity Costs for TMWRF

Meter	2009 ($)	2010 ($)	2011 ($)	2012[1] ($)
939286-260437	2,000,614	1,974,944	2,225,683	1,646,245
102938-465539	268,355	247,172	223,786	204,679
102938-149850	56,684	39,748	54,394	41,418
Total ($)	**$2,325,653**	**$2,261,864**	**$2,503,863**	**$1,892,341**
Annual Average Influent Flow (MGD)	26.9	28.6	28.8	29.1
Days per Year	365	365	365	274
Total (kWh/MG Treated)	**$237**	**$217**	**$238**	**$237**

Notes:

Table 3.9. Electricity Costs for TMWRF

Meter	2009 ($)	2010 ($)	2011 ($)	2012[1] ($)

1. Thru September 2012

3.1.6 Electricity End-Use Analysis

In order to assess TMWRF's electricity use at the component level, an end-use analysis of the plant's equipment was performed. Because the majority of electricity consumption at TMWRF pertains to the treatment process, this analysis includes only process equipment. In addition, the analysis focused on large equipment with a minimum motor size of 5 HP. Smaller pumps, fans, and other small electrical loads are not included.

> Meter 260437

Table 3.11 shows the end-use analysis for meter 260437 (main meter). The analysis includes all major process equipment and its estimated energy consumption. The quantity of equipment refers to the number of equipment typically running during plant operation. Redundant pumps and motors are not included.

While most of the equipment operates 24/7 for 8,760 run-hours per year, some pieces of equipment run intermittently. It has been assumed that this equipment operates eight hours per day for a total of 2,912 hours per year. Additionally, it has been assumed that pumps and motors with VFDs run at 75 percent speed (on average). Peak demands for VFD-equipped motors are calculated using 85 percent speed.

As shown in Table 3.10, the end-use estimate of peak kW for the main meter is 3,638 kW compared to the baseline 3,893 kW (reference Table 3.6). The lower end-use estimation is expected because non-process related equipment and smaller electrical loads were excluded from the analysis. Annual kWh consumption from the end-use estimate is 25.5 million kWh compared to the baseline 28 million kWh (reference Table 3.5). The lower kWh end-use estimate is primarily due to the exclusion of some non-process related equipment.

Table 3.10. End-Use Analysis of Electricity Consumption at the Main Meter 260437

Process	Equipment	Quantity	Size (HP)	Run Hours	Peak kW	Annual kWh
Headworks	Raw Sewage Pumps (VFD)	2	500	8,760	458	2,756,936
Grit Removal	Grit Pumps	2	20	8,760	30	261,398
Primary Clarifiers	Sludge Pumps (VFD)	7	15	2,912	48	96,228
	Scum Pumps (VFD)	7	15	2,912	48	96,228
Aeration Basins	Blowers	2	900	8,760	1,343	11,762,928
Secondary Clarifiers	Sludge Pumps (VFD)	14	30	8,760	192	1,157,913
	Scum Pumps (VFD)	2	15	2,912	14	27,494
Nitrifying Towers	Tower Feed Pumps (VFD)	2	200	8,760	183	1,102,775
	Towers 1-4 Blowers	4	25	8,760	75	653,496
	Towers 5-6 Blowers	1	10	8,760	7	65,350
Nitrifying Snail Control	Recirculation Pumps	2	100	2,912	149	434,470
Denitrification Reactor	Reactor Feed Pumps (VFD)	2	400	8,760	367	2,205,549
Post Aeration	Jet Aeration Pumps (VFD)	2	25	8,760	23	137,847
Dual Media Filters	Backwash Pump (VFD)	1	200	2,912	92	183,292
	Air Scour Compressor	1	15	2,912	11	32,585
	Backwash Waste Pump	1	60	2,912	45	130,341
Dechlorination	Paddle Mixer	1	14	8,760	10	91,489
Plant No. 2 Water	Horizontal Split Case Pumps	1	100	8,760	75	653,496
Primary Sludge Thickening	Thickener Sludge Pumps	1	20	8,760	15	130,699
	Thickener Scum Pumps	1	20	2,912	15	43,447
WAS Thickening	DAFT Pressurization Pumps	1	60	8,760	45	392,098
	Thickened Sludge Pumps	1	20	8,760	15	130,699
Sludge Digestion	APD Mixing Pump	1	40	8,760	30	261,398
	APD Recirculation Pumps (VFD)	2	30	8,760	27	165,416
	APD-MPD Transfer Pumps (VFD)	1	20	8,760	9	55,139
	MPD Mixing Pumps (VFD)	3	75	8,760	103	620,311
Sludge Dewatering	Centrifuge Main Drives	1	175	8,760	131	1,143,618
	Alum-Centrate Pedal Mixer	2	15	8,760	22	196,049
Heat Loop	Circulation Pumps - Centrifugal	1	10	8,760	7	65,350
	Circulation Pumps - Centrifugal	1	20	8,760	15	130,699
	Circulation Pumps - Centrifugal	1	15	8,760	11	98,024
	Circulation Pumps - Centrifugal	1	15	8,760	11	98,024
	Circulation Pumps - Centrifugal	1	15	8,760	11	98,024
		Total			**3,638**	**25,478,813**
		Baseline			**3,893**	**28,078,205**
		Difference			**-6.6%**	**-9.3%**

> Meter 465539

Table 3.11 shows the end-use analysis for the reuse irrigation pump meter 465539. There are four 700 HP pumps at the station, but only two pumps are in operation during a given time period. The peak kW estimate is calculated using 90 percent pump efficiency. The pumps are assumed to run continuously for five months of the year. The estimated peak demand is slightly higher than the peak kW recorded (see Table 3.7). The end-use estimate for kWh consumption is lower than the baseline (see Table 3.5).

Table 3.11. End-Use Analysis of Electricity Consumption at Meter 465539

Process	Equipment	Quantity	Size (HP)	Run Hours	Peak kW	Annual kWh
Effluent Reuse Pumping	Vertical Turbine Pumps	2	700	3,960	1,160	2,088,800
		Total			**1,160**	**2,088,800**
		Baseline			**1,123**	**2,210,600**
		Difference			**3.3%**	**-5.5%**

> Meter 149850

The end-use analysis for meter 149850 is shown in Table 3.12. The meter services a small reuse irrigation jockey pump with a VFD. The pump is assumed to run six months of the year. Peak demand of the pump is calculated using 90 percent VFD speed. The analysis also includes electrical loads for A/C, lighting, and shop equipment used in the Maintenance/Warehouse and Training Buildings. The buildings are assumed to be occupied eight hours per day and require A/C four months per year. The peak demand and kWh consumption from the end-use analysis are lower than the baseline (see Table 3.5 and Table 3.8), but are within reasonable tolerance.

Table 3.12. End-Use Analysis of Electricity Consumption at Meter 149850

Process	Equipment	Quantity	Size (HP)	Run Hours	Peak kW	Annual kWh
Effluent Reuse Pumping	Small Jockey Pump (VFD)	1	250	4,320	136	412,508
Maintenance Building	Building A/C (10 ton)	1	10	960	10	9,600
	Lighting	1	18	2,880	18	51,840
	Shop Equipment	1	35	360	35	12,600
Training Building	Building A/C (4 ton)	1	4	960	4	3,840
	Lighting	1	2	2,880	2	5,760
		Total			**205**	**496,148**
		Baseline			**224**	**531,785**
		Difference			**-8.5%**	**-6.7%**

3.2 Natural Gas and Propane

There is no natural gas service at TMWRF. Almost all heating needs at TMWRF are provided by the biogas generated from on-site digesters or by electric heaters.

The biogas has 60 percent methane content with a heating value of 550 British thermal units per cubic foot (Btu/CF). Approximately 30,000 to 33,000 SCFH of biogas is generated by the digesters. Currently, about half of this biogas is used as fuel to generate heating; the rest is flared. Based on this operation, the thermal need of the TMWRF from the biogas is estimated to be approximately 67,000 MMBtu per year.

The biogas is used at two boilers to generate the hot water distributed to the facility's buildings for heating. Five sludge heaters also use the biogas to provide heat to the methane digesters. Previously, TMWRF also generated heating hot water from the biogas cogeneration system; however, this system was decommissioned in 2010.

Additionally, propane is used as heating fuel at the Maintenance/Warehouse and Training Buildings. This fuel is supplied from two 1,075 gallon propane tanks located outside the buildings. The tanks are filled whenever necessary. The unit price paid for propane varies monthly. For 2011, the total propane cost for TMWRF was $38,442.

3.3 Water and Sewer

The City of Sparks provides domestic water and sewer services for TMWRF. Domestic water is used for restrooms, showers, and other typical plumbing fixtures. TMWRF also uses the water for pump seals, cooling water, wash down, and other process-related purposes. TMWRF uses very little domestic water because of the low occupancy at the plant. In 2011, the total annual cost for water and sewer services was $1,788.

3.4 Chemicals

The types of chemicals used in the treatment process are shown in Table 3.13. Some of the chemicals have very specific uses. Methanol, for example, is used solely as a carbon source for the denitrification process. Others, however, have multiple purposes and are used at many stages of the treatment process, such as sodium hydroxide for pH control.

Table 3.13. Chemicals Used at TMWRF

Chemicals	Process Use
Aluminum Sulfate	Primary and secondary sedimentation; Phosphor removal; Waste filter backwash
Dewatering Polymer	Solids dewatering
Ferric Chloride	Primary and secondary sedimentation; Waste filter backwash
Methanol	Denitrification
Sodium Bisulfate	Disinfection
Sodium Hydroxide	pH control
Sodium Hypochlorite	Disinfection; Post-aeration
Other Chemicals	
Phosphoric Acid	Aeration; Post-aeration
Flosperse 30	Struvite inhibitor
Descaler	Scale inhibitor
Flofoam	Foam control
Flopam D-45	Foam control

3.4.1 Chemical Consumption

Table 3.14 lists the annual consumption of the chemicals at TMWRF during the past three years. The consumption values are shown based on a fiscal year that runs from July 1 to June 30. Overall, the consumption has been stable over the last three years. There is a small trend of increasing chemical use year-over-year due primarily to the increased influent flow to the plant.

Table 3.14. Chemical Consumption at TMWRF

Chemical	Unit	FY 09-10	FY 10-11	FY 11-12	Baseline (average)[1]
Aluminum Sulfate	Ton	243	296	1,244	1,439
Dewatering Polymer	Pounds	1,087,940	966,020	931,991	995,317
Ferric Chloride	Ton	671	692	116	116
Methanol	Gallon	908,631	1,108,357	1,114,217	1,043,735
Sodium Bisulfate	Ton	196	258	262	239
Sodium Hydroxide	Ton	46	25	28	33
Sodium Hypochlorite	Gallon	667,357	798,684	661,938	709,326
Other Chemicals					
Phosphoric Acid	Gallon	7,238	10,857	17,822	11,972
Flosperse 30	Pounds	15,600	7,755	22,860	22,860
Descaler	Gallon	330	110	330	257
Flofoam	Gallon	6,500	8,250		7,375

Notes:

1. See explanation on Aluminum Sulfate annual baseline described below.

One exception to this trend is the large difference in annual consumption of aluminum sulfate and ferric chloride between fiscal years FY 2010-11 and FY 2011-12. In FY 2011-12, aluminum sulfate replaced ferric chloride for the phosphor removal system (PRS) in the centrate stream in order to reduce struvite build-up. Because of this change, aluminum sulfate consumption increased significantly, while ferric chloride consumption simultaneously decreased.

The baseline chemical consumption shown in Table 3.14 is the average of the three-year consumption. However, the last 12 months of aluminum sulfate and ferric chloride consumption is used as the baseline because of the usage change. The last 12 month of consumption is also used as the baseline for flosperse 30 because it is likewise involved in the struvite prevention effort that prompted the ferric chloride to aluminum sulfate chemical change.

Data for aluminum sulfate after TMWRF made the chemical switch was only available from September 2011 to June 2012. To create an annual baseline that reflects the latest usage, the average of the previous two years consumption (FY 2009-10 and FY 2010-11) was subtracted from the last 12 months of data. The result was then annualized to project the 10 months data to 12 months.

The methodology is as follows:

Baseline non-PRS Alum use = (243 + 296) / 2 = 269.5

Baseline monthly PRS Alum use = (1,244 – 269.5) / 10 = 97.45

Baseline annual PRS Alum use = 97.45 x 12 months = 1,169.4

Baseline total Alum use = 269.5 + 1,169.4 = 1,438.9

3.4.2 Chemical Costs

Table 3.15 shows the breakdown of chemical costs for TMWRF for the past three fiscal years. As in the consumption profile, the total cost profile has been relatively stable over the past three years. The annual increase in the chemical cost is primarily due to the increase in influent flow to the plant.

It is important to note that chemical cost is the largest utility spending for TMWRF. Annually, it costs TMWRF over $4.3 million to procure chemicals for process use, compared to $2.5 million of total electricity cost. Methanol and dewatering polymer are the two most expensive chemicals and annually account for 70 percent of the total chemical cost to the plant. Aluminum sulfate and sodium hypochlorite are the next two most expensive chemicals and account for 23 percent of TMWRF's annual total chemical costs.

Table 3.15. Chemical Costs at TMWRF

Chemical	Unit	FY 09-10 ($)	FY 10-11 ($)	FY 11-12 ($)
Aluminum Sulfate	Ton	96,995	111,529	482,976
Dewatering Polymer	Pounds	1,033,543	933,546	1,003,691
Ferric Chloride	Ton	498,461	515,050	85,740
Methanol	Gallon	1,740,503	1,893,386	1,994,464
Sodium Bisulfate	Ton	124,382	168,078	180,988
Sodium Hydroxide	Ton	30,016	17,974	19,431
Sodium Hypochlorite	Gallon	499,758	560,068	496,801
Other Chemicals				
Phosphoric Acid	Gallon	8,861	12,521	21,101
Flosperse 30	Pounds	15,912	13,515	25,062
Descaler	Gallon	18,370	6,232	19,119
Flofoam	Gallon	17,938	16,913	
Flopam D-45	Gallon	8,536		
	Totals ($)	**$4,093,276**	**$4,248,812**	**$4,329,375**

3.4.3 Chemical Prices

TMWRF procures chemicals from the vendors listed in Table 3.16 via contracts between City of Sparks and the vendor. Unit prices for the chemicals purchased are fixed for the term of the contract. Contract length typically ranges from 6 to 12 months. Typically, the city has the option to renew the contract for several cycles before it has to renegotiate the contract price. While some contracts include the anticipated quantity of chemicals to be purchased, there is no minimum quantity required. The contracts do not include penalty clauses for not purchasing the expected quantity of a given chemical.

Table 3.16. Chemical Prices and Contracts at TMWRF

Chemical	Unit	Unit Price ($)	Vendor	Contract Expiration	Renewal Length
Aluminum Sulfate	Ton	$385	Thatcher Company	January 10, 2014	One year
Dewatering Polymer	Pounds	$1.07	Polydyne	June 30, 2013	Six months
Ferric Chloride	Ton	$743.24	Kemira Water Solutions	June 30, 2014	Six months
Methanol	Gallon	$1.782	Brenntag Pacific	October 31, 2013	One year
Sodium Bisulfate	Ton	$690.11	Sierra Chemical Company	February 14, 2014	Six months
Sodium Hydroxide	Ton	$700	Sierra Chemical Company	June 30, 2013	Three months
Sodium Hypochlorite	Gallon	$0.746	Sierra Chemical Company	June 30, 2019	Six months

3.5 Waste Collection and Disposal

TMWRF produces two different types of waste: general waste and waste generated from the treatment process.

> General Waste

General waste and trash at the plant is serviced by Waste Management, Inc. Collection containers include three 4 yard bins and two 4 yard recycling bins located throughout the plant.

> Treatment Process

There are three types of wastes generated from the treatment process:

1. Grit and sand from the grit removal process: Collected in one 20 yard roll off bin before being removed from site by Waste Management.
2. Screened sludge from the gravity thickeners: collected in one 24 yard compactor next to the Primary Screening Building for removal off-site, also by Waste Management.
3. Biosolids sludge from the dewatering facility: collected at the Solids Dewatering Facility before it is hauled by Western Nevada Transport to Lockwood Landfill for final disposal.
    - Waste Management owns and operates the landfill. TMWRF pays both hauling fees and disposal fees for the biosolids sludge.

Table 3.17 on the following page lists the waste collection and disposal system at the plant.

Table 3.17. Waste Collection and Disposal at TMWRF

Waste	Vendor	Collection	Collection Frequency
General Trash	Waste Management	Three 4 yard bins	Once per week
Recycling Trash	Waste Management	Two 4 yard bins	Once per week
Grit and Sand	Waste Management	One 20 yard roll-off bin	Once per week
Screened Sludge	Waste Management	One 24 yard compactor	Once per week
Biosolids Hauling	Western NV Transport	Four Hopper silos	Five times per day (typically)
Biosolids Disposal	Waste Management	Lockwood Landfill	Five times per day (typically)

Similar to chemicals procurement, waste collection and disposal service fees for the plant are fixed by a contract between City of Sparks and Waste Management and Western NV Transport. Table 3.18 shows the contract prices for the waste collection and disposal fees. General waste hauling is billed as one account; the price is fixed per month. Grit and screened sludge hauling are also billed as one account; the price is likewise fixed because they are picked up at a regular frequency.

Western NV Transport charges $99.90 per pickup with an average of 5 to 6 pickups per day at approximately 22 tons of sludge per pickup. In addition, the company charges a fuel adjustment fee for the actual cost of fuel above or below the base fuel price of $2.85 per gallon. For final disposal at the landfill, Waste Management charges $10.80 per ton of sludge disposed. TMWRF is also charged fuel surcharge and environmental fees in addition to the tipping fee.

The contract for Waste Management services is renewed for a two year period at a time, while that for Western NV Transport's services is renewed annually.

Table 3.18. Waste Collection and Disposal Fees

Service	Fees	Vendor
General Waste Pick-Up		
1. General Trash	$602.80 per month	Waste Management
2. Recycling Trash	$236.39 per month	
3. Fuel/Environmental Fee	$177.17 per month	
Screening and Grit Removal		
1. Grit Removal	$164.69 per pick-up	Waste Management
2. Screening Removal	$155.37 per pick-up	
3. Fuel/Environmental Fee	$167.51 per month	
Biosolids Sludge Hauling		
1. Sludge Hauling	$99.90 per pick-up	Western Nevada Transport
2. Fuel Adjustment	Base fuel use is 6.5 gal per pick up at $2.85 per gal. Customer pays actual difference in the price of fuel used.	

Table 3.19 shows the total cost for waste collection and disposal at the plant for the past three years. As with chemical costs, the costs are for a fiscal year that runs from July 1 to June 30. Total cost for waste collection and disposal at the plant is approximately $800,000 per year. Biosolids disposal constitutes

the biggest part of the total cost at 70 percent of the total spend, followed by biosolids hauling cost at 25 percent of the total spend. The rest of the costs are minimal in comparison.

Table 3.19. Waste Collection and Disposal Costs, FY 09/10-11/12

Service	FY 09-10 ($)	FY 10-11 ($)	FY 11-12 (S)
Biosolids Sludge Hauling	263,217	246,245	208,635
Biosolids Disposal	492,867	583,442	548,954
Screening & Grit Removal	14,395	14,250	15,880
General Trash Pick-up	10,859	12,879	12,235
Additional Recycling		288	1,548
PCS paint Removal			557
Totals	**$781,338**	**$857,103**	**$787,808**

Table 3.20 shows the quantity of biosolids sludge disposed and the pick-up service performed that incurred the costs listed in Table 3.19. Table 3.20 only includes the quantity of biosolids waste because it is the only waste that varies depending on the amount of wastewater treated at the plant. Pick-up frequency for the other disposal services are regular services as agreed in the contract. The baseline quantity for the services is the average quantity (i.e., trip or tons of sludge) over the three year period.

Table 3.20. Annual Biosolids Sludge Production and Pick-up Frequency

Service	Unit	FY 09-10	FY 10-11	FY 11-12	Baseline (average)
Biosolids Sludge Hauling	Trips	2,026	2,262	2,088	2,126
Biosolids Disposal	Tons of sludge	45,467	49,077	44,762	46,435

The plant produces approximately 46,435 tons of biosolids sludge annually that are disposed at the landfill. Hauling biosolids from the plant to the landfill requires, on average, 2,126 trips per year or 5.8 pick-ups per day.

3.6 Utility Prices Escalation

To account for the increase in utility prices during the 15 year performance period, the unit utility prices are escalated annually. The escalation rates used in the project vary depending on the utility. Table 3.21 lists the utility price escalation rates used for the development of this project.

Table 3.21. Utility Price Escalation Rates[1]

Utility	Index	Annual Escalation Rate (%)
Electricity	NIST Energy Price Indices	2.89
Chemicals	NIST Energy Price Indices	2.89
Sludge Hauling	U.S. EIA Transportation Fuel Price Indices	3.19
Sludge Disposal	U.S. DoL BLS – Consumer Price Indices	2.38
Operations & Maintenance	U.S. DoL BLS – Consumer Price Indices	2.38

Notes:

1. Assumed 3 percent general inflation.

Electricity

A fixed annual escalation rate of 2.89 percent was used. The rate is calculated based on the 2013 Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis published by the National Institute for Standards and Testing (NIST). Table S-4 of that document provides the projected fuel price indices with general price inflation for commercial customers in Census Region 4, which includes the State of Nevada. Based on the information presented by NIST, electricity prices for the region are projected to increase from the normalized index of 1.03 in 2013 to 1.58 in 2028 for an annual compound rate of 2.89 percent. The general inflation rate used in the calculation is 3 percent. Please reference Appendix A for a copy of Table S-4.

Chemicals

There are no national guidelines for the projected increase in chemical prices. For this project, we assume that chemical prices will increase at the same rate as electricity prices at 2.89 percent per year. Because most of the chemicals used at TMWRF are manufactured, price increases are likely to closely follow electricity price increases. As before, we assume a general inflation rate of 3 percent.

Biosolids Sludge Hauling

Savings from biosolids sludge hauling is directly correlated to the price of transportation fuel. An escalation rate of 3.19 percent has been assumed for this fuel. This rate is calculated based on the energy price indices published by U.S. Energy Information Administration (EIA). Diesel fuel is projected to increase from $26.54 per million Btu (MMBtu) in 2013 to $42.50 per MMBtu in 2028. The dollar amount is shown in nominal dollars including 3 percent inflation. Based on these prices, the annual compound rate is calculated to be 3.19 percent.

Operations and Maintenance

The project will incur an annual Operations & Maintenance (O&M) expense. To account for the increase in this expense, the O&M cost is escalated by 2.38 percent annually in the proforma. The rate increase is based on the Consumer Price Index for urban consumers (CPI-U) in Nevada. Data for the CPI-U index is taken from U.S. Department of Labor Bureau of Labor Statistics 2012 publication for the Western

Region. The 2.38 percent escalation rate is the average of the annual CPI-U increase in the months of 2012 compared to those in 2011.

Per guidelines from the City of Reno, savings from biosolids disposal is also tied to the Nevada CPI, which is 2.38 percent.

3.7 Utility Incentives

3.7.1 Nevada Energy Incentives

The Public Utility Commission of Nevada (PUCN) offers an incentive program known as the SureBet Program. This program focuses on helping businesses and institutions use energy wisely. An application for the incentives can be submitted for prescriptive or custom projects. Ameresco anticipates this energy saving project will qualify for incentives for the lighting retrofit.

The incentive amount available for a lighting retrofit varies depending upon the types of retrofit conducted. The incentive for replacing standard 32 W T8 fixtures to premium efficiency 25 W T8 fixtures is $1.00 per fixture. Please reference the appendix for a copy of the SureBet program summary for Northern Nevada. The actual rebate amount will be determined when the rebate applications are submitted to the utility at the beginning of construction.

3.7.2 Renewable Energy Credits

TMWRF has an existing contract in place with NV Energy to sell the Renewable Energy Credits (RECs) created from on-site power generation. The existing REC purchase price is $0.005/kWh. We are including the revenue from selling the RECs to the savings stream in the biogas cogeneration ECM.

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4.0 Energy Conservation Measures

This section outlines the detailed scopes of work for the Energy Conservation Measures (ECMs) that comprise the proposed project for TMWRF. Section 4.0 provides a description of the existing conditions and proposed retrofits, an analysis of the projected energy savings, and detailed scopes of work for each ECM. The impact that these measures will have on the operations at TMWRF has also been documented.

Methanol tanks for the denitrification process.

Ameresco has developed seven ECMs that will help TMWRF reduce overall operation costs through a combination of retrofits and equipment replacements. Table 4.1 summarizes the ECMs proposed in this FGOA.

Table 4.1. Proposed Energy Conservation Measures

Energy Conservation Measures	
ECM 2:	Centrate Nutrient Recovery (Ostara)
ECM 4A:	Biogas Cogeneration System - 850 kW
ECM 4B:	Digester Domes Rehabilitation
ECM 6:	Dewatering System Upgrade
ECM 7:	Lighting System Upgrade
ECM 9:	Near-Term Dewatering Improvement
ECM 10:	MyEnergyPro™

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4.1 Financial Overview

Please reference Table 4.2 for the projected utility savings for these ECMs. Table 4.3 and **Error! Reference source not found.** respectively provide a summary of the cost savings and construction costs.

Table 4.2. Summary of Energy and Utility Savings

Energy Conservation Measure	Annual Demand Savings (kW)	Annual Electricity Savings (kWh)	Annual Methanol Savings (Gal)	Annual Alum Savings (Ton)	Annual Fertilizer Production (Ton)	Hauling Pickup Savings (Trip)	Landfill Disposal Savings (Ton)
ECM 2: Centrate Nutrient Recovery (Ostara)	(470)	(343,085)	29,895	1,155	562	108	2,474
ECM 4A: 850 kW Biogas Cogeneration System	0	5,696,190	0	0	0	0	0
ECM 4B: Digester Domes Rehabilitation	0	0	0	0	0	0	0
ECM 6: Dewatering System Upgrade	134	98,024	0	0	0	525	12,069
ECM 7: Lighting System Upgrade	199	366,606	0	0	0	0	0
ECM 9: Near-Term Dewatering Improvement	0	0	0	0	0	0	0
ECM 10: MyEnergyPro™	0	0	0	0	0	0	0
Totals	**(137)**	**5,817,735**	**29,895**	**1,155**	**562**	**633**	**14,543**

Table 4.3. Summary of Cost Savings by Type

Energy Conservation Measure	Annual Electricity Savings ($)	Annual Methanol Savings ($)	Annual Aluminum Savings ($)	Annual Fertilizer Savings ($)	Hauling Pick-up Savings ($)	Landfill Disposal Fee ($)	O&M Costs ($)	Total Annual Savings ($)
ECM 2: Centrate Nutrient Recovery (Ostara)	(26,402)	53,273	444,817	140,424	10,789	28,901	24,183	675,985
ECM 4A: 850 kW Biogas Cogeneration System	343,233	0	0	0	0	0	($127,719)	215,514
ECM 4B: Digester Domes Rehabilitation	0	0	0	0	0	0	0	0
ECM 6: Dewatering System Upgrade	7,543	0	0	0	52,448	140,963	0	200,954
ECM 7: Lighting System Upgrade	25,675	0	0	0	0	0	4,759	30,434
ECM 9: Near-Term Dewatering Improvement	0	0	0	0	0	0	0	0
ECM 10: MyEnergyPro™	0	0	0	0	0	0	0	0
Totals	**$350,049**	**$53,273**	**$444,817**	**$140,424**	**$63,237**	**$169,864**	**($98,977)**	**$1,122,887**

Table 4.4. Summary of Construction Costs

Energy Conservation Measure	Total Annual Savings ($)	Energy/Chemical Project Cost ($)	Capital Repair Items ($)	Total Cost ($)	Utility Rebate ($)
ECM 2: Centrate Nutrient Recovery (Ostara)	675,985	6,760,860		6,760,860	0
ECM 4A: 850 kW Biogas Cogeneration System	215,514		5,116,967	5,116,967	0
ECM 4B: Digester Domes Rehabilitation	0		3,121,795	3,121,795	0
ECM 6: Dewatering System Upgrade	200,954	6,066,614		6,066,614	0
ECM 7: Lighting System Upgrade	30,434	428,761		428,761	15,995
ECM 9: Near-Term Dewatering Improvement	0		3,005,202	3,005,202	0
ECM 10: MyEnergyPro™	0	50,625		50,625	0
TOTAL	**$1,122,887**	**$13,306,860**	**$11,243,964**	**$24,550,824**	**$15,995**
Construction Period Savings	**$1,044,422**				
Simple Payback with Cogen Savings (Years)		**10.9**	**N/A**	**20.8**	
Simple Payback without Cogen Savings (Years)		**13.5**	**N/A**	**N/A**	

4.2 ECM 2: Centrate Nutrient Recovery (Ostara)

4.2.1 Overview

The recycled steam from solids handling (centrate) introduces additional nitrogen and phosphorous loads to the wastewater treatment process. This ECM proposes to remove the additional phosphorous load through a struvite precipitation process. Phosphate removal through struvite precipitation has gained popularity in recent years due to its importance as a sustainable practice, application in managing facility nutrient recycle loads, and pipe scaling management. Currently, TMWRF removes phosphate from the centrate by chemical means with the addition of aluminum sulfate (alum). Implementing this ECM will eliminate the chemical cost of the existing phosphorous removal system, as well as generate an income stream for TMWRF by selling the fertilizer produced during the process.

4.2.2 Recommendations

Ameresco recommends TMWRF to install the Pearl nutrient recovery system at the plant. The Pearl process is a proprietary nutrient recovery technology developed by Ostara Nutrient Recovery Technologies, Inc. It is an environmentally sustainable centrate treatment solution that extracts nutrients and transforms them into a slow-release fertilizer. Ostara then markets the fertilizer to commercial fertilizer users under its Crystal Green brand.

The Pearl process chemically precipitates struvite, a material comprised of magnesium, ammonium, and phosphate, by adding magnesium to increase ionic concentration and sodium hydroxide to increase the pH of the struvite. Conditions are carefully controlled to form struvite pellets with consistent physical and chemical properties to meet fertilizer standards. The centrate is treated continuously, and the product is dried and bagged on site. Figure 4.1 shows a schematic diagram of the Pearl process. A more detailed description of the technology is provided in Ostara's proposal for Nutrient Recovery at TMWRF, included as Appendix D.

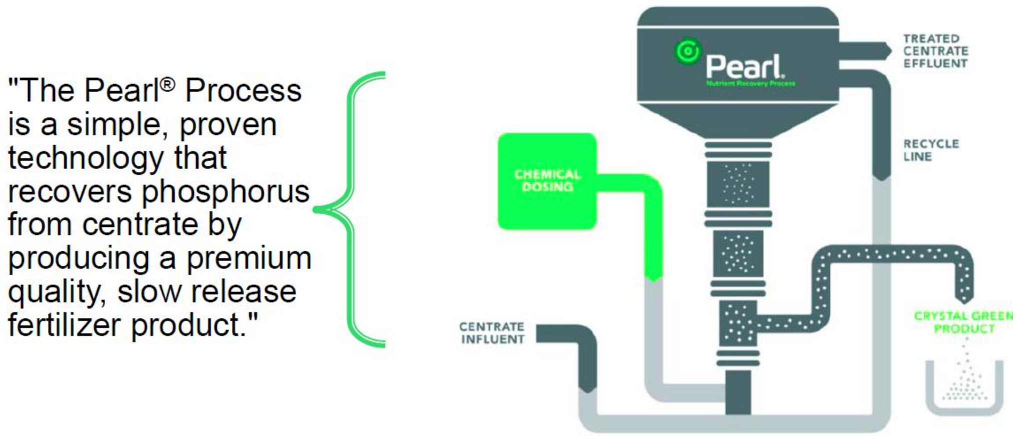


Figure 4.1. Schematic Diagram of the Pearl Process

Table 4.5 provides the parameters used in the preliminary design of the system. These parameters are based on TMWRF's operating data from July 2011 to June 2012. They also form the baseline for the savings guarantee.

Table 4.5. Baseline Design Parameters for the Pearl Nutrient Recovery Process

Item	Unit	Average	Min	Max
Centrate Flow Rate	GPM	165	108	239
Magnesium Concentration	mg/L	110	N/A	N/A
Ammonia Concentration	mg/L NH_3-N	1,400	990	1,600
Ammonia Load	lbs/day	2,622	1,656	3,525
Orthophosphate Concentration	mg/L PO_4-P	230	170	340
Orthophosphate Load	lbs/day	467	290	740
pH	SU	7.4	7.1	7.5

The Pearl process is operated to achieve a design effluent orthophosphate concentration. A target effluent quality of 16 mg/L PO_4-P (phosphate) has been designed for this application, which will require operating at a pH of approximately 7.55. This target effluent quality translates to removing 93 percent of the orthophosphate from the centrate based on the pilot study conducted in 2008. In terms of orthophosphate mass removal, the target mass removal is 435 lbs/day of PO_4-P on average. This will result in an average effluent orthophosphate load of 32 lbs/day with a 46 lbs/day maximum. For comparison, effluent from the existing phosphorous removal system has produced average orthophosphate loads of 41 lbs/day average with a 216 lbs/day maximum.

For the design removal targets, we propose installing one Pearl 2000 Reactor that has a nominal capacity to remove 550 lbs/day of orthophosphate. The process is inherently flexible and can be loaded up to 50 percent above nominal design (i.e., 833 lbs/day) for up to a month. In addition to the reactor, the process also requires a chemical dosing system for magnesium chloride and sodium hydroxide and a product handling system for drying, classifying, and bagging the fertilizer pellets produced. A strainer will also be included to prevent contaminants from entering the Pearl reactor. Preliminary process diagrams of the system are provided in Appendix D.

We propose to house all of the new equipment in a new 3,000 SF pre-engineered building located southeast of the Solids Dewatering Facility. This location was selected from four potential locations after consultation with TMWRF. It was selected to minimize the centrate pipe run from the Solids Dewatering Facility, as well as to avoid impeding existing underground utilities. Figure 4.2 shows the proposed location of the new Ostara Building at TMWRF.

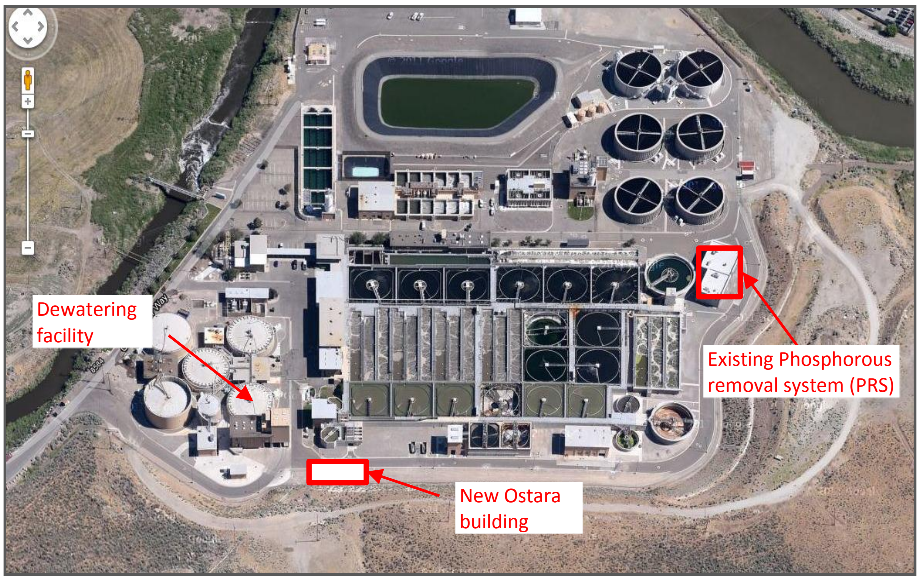


Figure 4.2. Proposed Location for New Ostara Building

A CO_2 injection system will replace the expensive and proprietary flosperse chemical that TMWRF currently uses to prevent struvite formation in the centrate pipes. Existing centrate pumps in the Solids Dewatering Facility will be replaced with larger pumps to accommodate the required pressure head for the Pearl reactor. Treated centrate water from the reactor will be returned to the main process via a gravity feed.

Electricity for the new building will be supplied from the Low Voltage Distribution Center 2 (LVDC 2) in Gallery A. Other utilities for the building will include potable water, hot water, and compressed air from TMWRF's existing services in the nearest galleries. Preliminary schematics for the electricity and utility tie-ins are provided in Appendix D.

4.2.3 Scope of Work

Construction for this ECM will be a design-build delivery method to expedite installation. We will prepare engineering drawings to the detail required for permit acquisition and construction. We will have the pertinent drawings stamped by a Nevada Professional Engineer (PE), as required. Redline drawings to document the as-built facility will be provided at the completion of construction.

The following is a summary of the scope of work for this ECM. All preliminary design diagrams referenced in the description are provided in Appendix D.

- Installation of the Pearl process using one Pearl 2000 Reactor, including all mechanical and electrical equipment required as per the Piping & Instrumentation Diagram (Drawings #B1025-1-501 to 506 Rev C).
- Installation of Crystal Green fertilizer drying, classifying, storage, and bagging systems, including all mechanical and electrical equipment required as per the Piping & Instrumentation Diagram (Drawings #B1025-1-501 to 506 Rev C).
- Construction of a pre-engineered, steel frame metal clad building to house the Pearl 2000 Reactor and Crystal Green fertilizer system (items one and two, above). This building will be non-continuously occupied and will include HVAC for freeze protection in the winter and minimal cooling in the summer. The building's MCC room will be air-conditioned to the temperature needed to protect the electronics. The design of the new building will be as shown (approximately) on the general arrangement drawings (Drawings #B1025-2-100 to 102 Rev C).
- Installation of chemical storage and dosing for caustic soda (sodium hydroxide) and magnesium chloride, including a heat traced caustic soda storage tank. The tanks will be installed outside on a concrete secondary containment structure.
- Construction of a three-sided enclosure on the west side of the new building, using the building as the back wall, for finished product storage. The storage area will be approximately 26 feet wide by 18 feet high by 13 feet deep.
  - The finished product will be stored on a pushback style racking system from Unarco with storage configuration of five pallets across by three pallets high by three pallets deep, for a total storage capacity of 45 pallets.
- Replace two existing 7.5 HP centrate delivery pumps with two new 25 HP centrate delivery pumps.
- Install tie-in to existing centrate pipe line in the corner where Gallery B meets Gallery C.
- Install provisions for a new gravity pipe line to return process effluent from the Pearl Reactor to the common grit removal channel.

- Install tie-in to existing non-potable water, potable water and instrument air services in the corner where Gallery B meets Gallery C.
- Install tie-in to site electrical power from a breaker in LVDC 2 in the galleries.

4.2.4 Baselines and Assumptions

The following baselines and assumptions were made in the development of this ECM:

- Baseline design parameters for the Pearl system are shown in Table 4.5. Guaranteed savings from reduced chemical use and fertilizer generation depends on these baseline parameters. If during the performance period the chemical composition of the centrate varies significantly from the baseline in that the projected savings is negatively impacted, a baseline adjustment may be necessary.
- The new Ostara Building will be constructed adjacent to the hill south of the plant. Ameresco will relocate the existing fence as necessary to accommodate the building. However, any excavation or earthwork of the hill is not included in this scope. Additional road construction or repair beyond that which is necessary for building access is also excluded.
- Ameresco will utilize the hot water system from the plant for the new Ostara Building. We assume that the supply hot water temperature is hot enough (160°F or greater) for use in the fertilizer drying system and that no separate heating system is needed.
- TMWRF will contract directly with Ostara Nutrient Recovery Technologies, Inc. for fertilizer product off-take and sale. Ameresco will track the sale invoices to verify that the savings are realized.
- The phosphorous stripping system at WAS prior to thickening and digestion as described in the 2008 pilot study is not included in this ECM.

4.2.5 Detailed Energy Analysis

Cost savings for this ECM comes from several sources listed below:

- Revenue from Crystal Green fertilizer production.
- Methanol savings from reduced ammonia content in the centrate.
- Aluminum Sulfate (alum) savings from reduced phosphorous content in the centrate.
- Biosolids hauling and disposal costs savings from reduced biosolids production.
- Polymer savings from reduced biosolids production.

There will be some increased chemical and utility costs from installing the Pearl process. Nonetheless, the savings far outweigh the increased costs. Anticipated additional costs are as follows:

- Increased caustic soda costs for use in the process.
- Additional cost of CO_2 to prevent struvite build-up in the pipes. This cost will be mitigated because flosperse will no longer be used in the process.
- Increased electricity cost from additional power usage.

Table 4.6 shows a summary of the costs for ECM 2.

Table 4.6. Summary of Cost for ECM 2

Source	Savings ($)	Additional Costs ($)
Fertilizer Revenue	140,424	
Methanol Savings	53,273	
Alum Savings	444,817	
Hauling Cost Savings	10,789	
Disposal Cost Savings	28,901	
Polymer Savings	56,750	
Fertilizer Revenue	140,424	
Subtotal Savings	***$734,955***	
Caustic Soda Cost		10,500
Carbon Dioxide Cost		8,128
Flosperse Savings	25,062	
Electricity Cost		26,402
O&M Cost		39,000
Subtotal Additional Costs		***$58,968***
Total Net Savings	**$675,986**	

> Fertilizer Revenue

The Pearl process will remove phosphorous and ammonia from the centrate and convert them to usable fertilizer. TMWRF will then sell the fertilizer to Ostara to realize a monthly revenue stream. Actual purchase price for the fertilizer will be contracted between TMWRF and Ostara directly. During ECM development, Ostara provided an offer price of $250 per ton for purchasing the fertilizer.

The amount of fertilizer produced is calculated based on the baseline chemical composition of the centrate shown in Table 4.27. The baseline orthophosphate load (P) load in the centrate is 467 lbs/day. The Pearl process is designed to remove 93 percent of the P. Therefore, the projected amount of P removed from the centrate is then:

Baseline P removed = Baseline P load x Removal rate

Baseline P removed = 467 lbs/day x 93%

Baseline P removed = 434 lbs/day

The precipitate fertilizer from the reactor is an equimolar crystalline matrix of magnesium, ammonium, and phosphate: $NH_4MgPO_4.6(H_2O)$. The molar ratio of P in the pellet is then 12.7 percent by weight. Using the projected 434 lbs/day of P removal, the theoretical amount of fertilizer produced is then:

Fertilizer produced = Baseline P removed / P weight ratio

Fertilizer produced = 434 lbs/day / 12.7%

Fertilizer produced = 3,420 lbs/day

However, not all the fertilizer produced meets the criteria for commercial sale due to the different sizes, shape, and other factors. From experience operating the Pearl process at other wastewater treatment plants, it was found that approximately 10 percent of the pellets are not commercial grade. The rejected pellets can be either returned back to the reactor for further processing or used for non-commercial use at TMWRF. Accounting for this rejection rate, the total annual amount of fertilizer production is then:

Annual fertilizer production = Fertilizer produced x (1 – Rejection rate) x 365 days/yr

Annual fertilizer production = 3,420 lbs/day x 90% x 365 days/yr

Annual fertilizer production = 1,123,470 lbs/yr / 2,000 tons/lb

Annual fertilizer production = 562 tons per year

Using the projected annual fertilizer production and the sale price, the annual revenue to TMWRF can then be calculated:

Annual fertilizer revenue = 562 tons/yr x $250/ton

Annual fertilizer revenue = $140,500 per year

> Methanol Savings

The produced fertilizer also contains N along with the P and Mg. From the chemical make-up of the fertilizer, the theoretical ratio of N to P in the compound is 0.45. There is 0.45 lb of N for every one pound of P. From the previous calculation, we found that the baseline P removal from the centrate is 434 lbs/day. Based on this, the amount of N that will be removed from the centrate can be calculated:

Baseline N removed = Baseline P removed x 0.45

Baseline N removed = 434 lbs/day x 0.45

Baseline N removed = 195 lbs/day

TMWRF uses methanol as a carbon source to remove ammonia in the main process. Removing ammonia in the centrate mitigates the need to use methanol in the main process to remove it. From historical data, the total ammonia load at the main process is 7,120 lbs/day; 2,622 lbs/day of that load is from the centrate. The ratio of N removal at the Pearl reactor compared to the total ammonia load is then:

% N removal = 195 lbs/day / 7,120 lbs/day

% N removal = 2.74 %

The amount of methanol used at TMWRF for ammonia removal is obtained from historical data. Figure 4.3 shows TMWRF's methanol use per day compared to ammonia load.

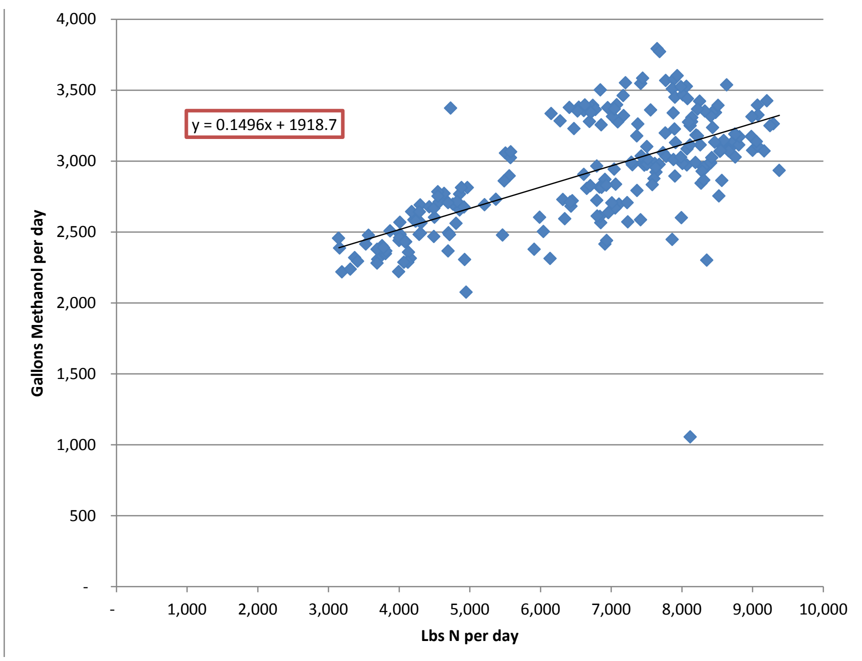


Figure 4.3. Historical Chart of Methanol Consumption versus Ammonia Load

First order linear regression of the data provides an estimate of the methanol use at the plant:

Methanol gal/day = 0.1496 (N lbs/day) + 1,918.7

For baseline total ammonia load of 7,120 lbs/day, the estimate methanol consumption is:

Baseline methanol use = 0.1496 x (7,120 lbs/day) + 1,918.7

Baseline methanol use = 2,984 gal/day

As seen from Figure 4.3, methanol consumption at TMWRF is relatively linear with the ammonia load. Consequently, the amount of methanol saved from N removal at the Pearl Reactor can be expected to be linearly proportional with the percent of N removed, as well:

Daily methanol savings = Baseline methanol use x % N removal

Daily methanol savings = 2,984 gal/day x 2.74%

Daily methanol savings = 82 gal/day

The annual methanol savings can then be calculated accordingly.

Annual methanol savings = Daily methanol savings x 365 days/yr

Annual methanol savings = 82 gal/day x 365 days/yr

Annual methanol savings = 29,895 gal/day

Monetary savings from methanol use reduction is then:

Methanol cost savings = Annual methanol savings x Methanol price

Methanol cost savings = 29,895 gal/day x $1.78/gal

Methanol cost savings = $53,273

> Alum Savings

The most significant monetary savings from installing the Pearl process is the reduction in alum use. Currently, TMWRF uses alum to remove phosphorous at the PRS. The PRS will not be used after the installation of the Pearl process, although it will be kept as a backup system.

The historical alum consumption at TMWRF at the PRS is obtained from SCADA and is shown in Figure 4.4.

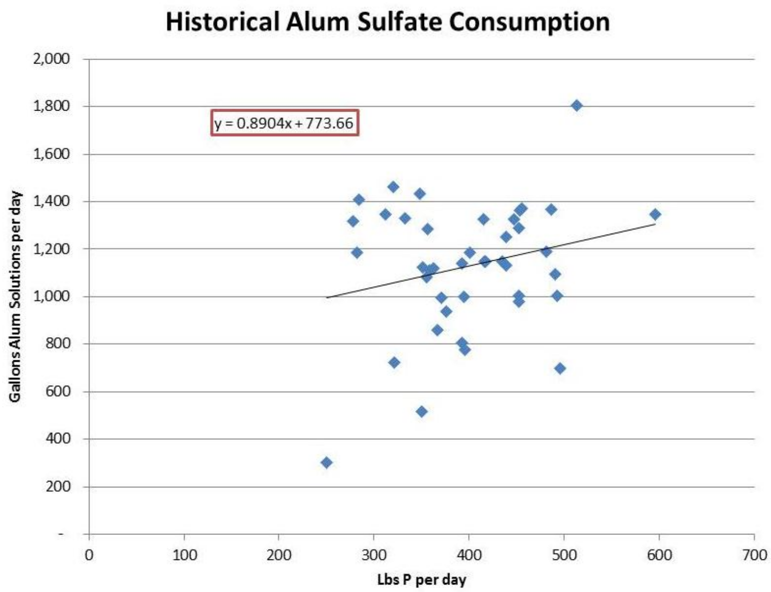


Figure 4.4. Historical Chart of Alum Consumption versus Phosphorous Load at the PRS

The linear approximation of alum consumption is obtained from the data as:

Alum solution gal/day = 0.8904 x P load lbs/day + 773.66

Baseline P removed from our previous calculation is 434 lbs/day. Using this number, the amount of alum solution saved 1,160 gallons per day. For a year, the savings is 423,535 gal/yr.

Alum solution savings = 0.8904 x 434 lbs/day + 773.66

Alum solution savings = 1,160 gal/day

Although TMWRF purchases the alum as a chemical solution, the price is determined by the amount of dry alum in the solution. The cost of alum is $385 per dry ton. To calculate the monetary savings from the reduction in use, the amount of dry alum in the amount of solution saved must be calculated. From the manufacturer's data, the supplied alum solution has a dry alum content of 48.8 percent; the density of the alum solution is 11.18 wet lbs/gal. The annual dry alum savings is then:

Annual dry alum savings = Annual alum solution savings x Solution density x % dry alum ratio

Annual dry alum savings = 423,535 gal/yr x 11.18 lbs/gal x 48.8%

Annual dry alum savings = 2,310,739 lbs/yr

Or in terms of tonnage:

Annual dry alum savings = 2,310,739 lbs/yr / 2,000 lbs/ton

Annual dry alum savings = 1,155 tons/yr

The cost savings from deferred alum use is then:

Alum cost savings = Annual dry alum savings x Alum price

Alum cost savings = 1,155 tons/yr x $385/ton

Alum cost savings = $444,817 / yr

> Biosolids Hauling and Disposal Savings

When alum is injected in the PRS, the alum forms Inert Suspended Solid (ISS) with phosphorous and other compounds, which will ultimately be precipitated out of the centrate as biosolids. Theoretically, the weight ratio of the dry ISS to the amount of P in the centrate is 4.87 lb/lb. Every pound of P when precipitated using alum will create 4.87 lbs of biosolids. Using this data, the amount of biosolids reduction due to alum and P removal is then:

Dry inert biosolids saving = Baseline P removed x 4.87 lb biosolid/lb P

Dry inert biosolids savings = 434 lbs/day x 4.87 lb/lb

Dry inert biosolids savings = 2,115 lbs/day

In practice, biosolids are hauled to the landfill wet because the centrifuges do not remove 100 percent of the water from the solids. Existing centrifuges at TMWRF have a dewatering capacity of 15.6 percent: in other words, the resulting wet biosolids contains 15.6 percent dry solids. Based on this capacity, the wet to dry biosolids ratio is 6.41 lb/lb. A pound of dry solid is equivalent to 6.41 lbs of wet solids that need to be hauled to the landfill.

Wet/dry biosolids ratio = 1 / 15.6%

Wet/dry biosolids ratio = 6.41 lb/lb

The amount of wet biosolids saved from the dry inert biosolids is then:

Daily biosolids savings = Dry inert biosolids savings x wet/dry biosolids ratio

Daily biosolids savings = 2,115 lbs/day x 6.41 lb/lb

Daily biosolids savings = 13,557 lbs/day

The annual biosolids savings from the Pearl process can then be calculated:

Annual biosolids savings = Daily biosolids savings x 365 days/yr / 2,000 lbs/ton

Annual biosolids savings = 13,557 lbs/day x 365 days/yr / 2,000 lbs/ton

Annual biosolids savings = 2,474 tons/yr

Hauling cost savings can be calculated based on the amount of biosolids saved. During the audit, the average hauling load of the pickup company is 23 tons per pick-up, and we assume that this will remain.

Hauling pick up saved = Annual biosolids savings / 23 tons/pick-up

Hauling pick up saved = 2,474 tons/yr / 23 tons/pick up

Hauling pick up saved = 108 pick-ups/yr

Hauling cost savings is then:

Hauling cost savings = Hauling pick up saved x Hauling unit price

Hauling cost savings = 108 pick-ups/yr x $99.90/pick-up

Hauling cost savings = $10,789/yr

The biosolids disposal cost at the landfill is calculated based on the tonnage of biosolids. Unit price of the tipping fee, including environmental fee and other charges imposed by Waste Management, is $11.68/tons. The annual disposal cost savings is then:

Disposal cost savings = Annual biosolids savings x tipping fee

Disposal cost savings = 2,474 tons/yr x $11.68/tons

Disposal cost savings = $28,900/yr

> Polymer Savings

TMWRF uses polymer in the dewatering process to remove water from the biosolids. The amount of polymer used is proportional to the amount of biosolids dewatered. Consequently, reducing the amount of biosolids produced will also reduce the amount of polymer used in the dewatering facility.

From previous calculation, we projected an annual biosolids savings of 2,474 tons/yr out of the baseline annual biosolids production of 46,435 tons/yr. The percentage savings for biosolids is then:

% biosolids savings = 2,474 tons/yr / 46,435 tons/yr

% biosolids savings = 5.33%

Based on utility data, the baseline polymer consumption at TMWRF is 995,317 lbs/yr at a unit price of $1.07 per pound. Based on the percent biosolids savings, the amount of polymer savings is as follows:

Polymer savings = Baseline annual polymer x % biosolids savings

Polymer savings = 995,317 lbs/yr x 5.33%

Polymer savings = 53,037 lbs/yr

Annual polymer cost savings is calculated based on the projected polymer savings and the unit price.

Polymer cost savings = Polymer savings x Unit price

Polymer cost savings = 53,037 lbs/yr x $1.07/lb

Polymer cost savings = $56,750 / yr

> Caustic Soda Cost

For the effluent design of 16 mg/L PO_4-P concentration, the Pearl process needs to operate at a pH of approximately 7.55. Historical pH levels of the centrate at TMWRF range from 7.1 to 7.5, with an average pH of 7.4. Caustic soda (sodium hydroxide) will be used to increase the pH as necessary to maintain the effluent design concentration.

The amount of caustic soda that will be needed for the process is difficult to determine beforehand due to the number of factors that affect the quantity required. In the 2008 pilot study at TMWRF, a small scale Pearl process did not require any caustic soda for pH adjustment. At other Pearl process installations, however, the maximum rate of caustic soda use is 65 mg NaOH per liter of centrate. The baseline centrate flow rate is 165 GPM (reference Table 4.26).

Max caustic soda = 65 mg/L x 165 gpm x 3.785 L/gal

Max caustic soda = 40.6 gr/min

The annual max caustic soda that will be needed is then:

Annual max caustic soda = 40.6 gr/min x 60 min/hr x 8,760 hr/yr x 1/1,000 kg/gr x 2.2 lbs/kg

Annual max caustic soda = 46,946 dry lbs / yr

Or in terms of tonnage:

Annual max caustic soda = 46,946 lbs/yr / 2,000 tons/lbs

Annual max caustic soda = 23.47 tons/yr

Please note that the maximum caustic soda calculation shown above is a “worst case scenario” calculation based on data from other wastewater treatment plants. During the 2008 pilot study at

TMWRF, the caustic soda needed was zero. For this project, it has been assumed that 15 tons per year of caustic soda will be required, which is 64 percent of the worst case maximum.

Based on that assumption, the additional cost to TMWRF for using caustic soda for the Pearl process is:

Caustic soda cost = 15 tons/yr x $700/ton

Caustic soda cost = $10,500 / yr

> Flosperse Savings and CO_2 Costs

TMWRF is currently using Flosperse, a proprietary chemical, to prevent struvite formation in the pipes. After the Pearl process installation, this chemical will be substituted with CO_2 gas, which is cheaper. The amount of Flosperse saved is determined using the annual utility bills. There is no theoretical means to calculate the actual Flosperse use because it is unique to each plant and condition.

Flosperse savings = $25,062 / yr

Upon project installation, TMWRF will use CO_2 gas in lieu of Flosperse. Like Flosperse, it is not possible to theoretically derive the amount of CO_2 that will be needed because it is unique to each plant. Nevertheless, Ostara reports that other Pearl process installations spend an average of $8,128 on CO_2. Therefore, this amount will be used in the financial analyses for TMWRF.

CO_2 cost = $8,128 / yr

> Electricity Cost

The new Pearl process will use electricity for pumps and building uses. The additional cost of electricity from this installation is calculated as follows.

Old centrate pump (removed) = - 7.5 HP

New centrate pump = 25 HP

New Pearl recycle pump = 25 HP

Building HVAC and others = 10 HP

Total additional power = 52.5 HP

The additional power for the new process is then:

Total additional power = 52.5 HP x 0.746 kW/HP

Total additional power = 39 kW

This additional electricity use will incur both peak kW demand cost and kWh energy cost. The monthly peak kW demand addition is then 39 kW, while the annual electricity use is as follows:

Annual electricity use = 39 kW x 8,760 hr/yr

Annual electricity use = 343,085 kWh / yr

The dollar cost savings from additional electricity use is calculated based on the time-of-use rate of the service. Detail of this cost calculation is provided in Appendix D. A summary of the cost savings is as follows:

Annual $ demand cost = $5,729 per year

Annual $ energy cost = $20,673 per year

Total annual $ electricity cost = $26,402 per year

> Maintenance Savings

The Pearl process is a highly automated system that requires minimal O&M. Once installed, Ostara will monitor the system remotely to ensure proper operation. Nevertheless, TMWRF does have several on-site responsibilities to properly operate and maintain the system. A fund to pay for these O&M needs has been included in the project's cash flow.

The following is a general overview of TMWRF's O&M responsibilities for this ECM. Detailed O&M activities for this ECM are provided in Appendix D.

- Visual inspection of the process and general housekeeping
- Fill product bags every 5 days (on average) and move to storage using a forklift
- Load the products to hauling truck every 3 weeks (on average)
- Collect samples for analysis
- Refill caustic soda as needed
- Receive magnesium chloride and fill tank
- Equipment calibration as necessary

Based on experience at other installations, O&M activities will require approximately 0.4 full time employees (FTE). Assuming $80,000 per year cost for one FTE, the additional labor cost to TMWRF for O&M is then:

New labor cost = 0.4 x $80,000 / yr

New labor cost = $32,000 per year

In addition to labor, there will also be cost for parts, replacements, and other general maintenance. Based on experience from other installations, it is estimated that this general maintenance cost will be $22,000 per year:

General maintenance cost = $22,000 per year

After Pearl process installation, the existing PRS will not be used anymore. The PRS incurs an O&M cost to TMWRF that will no longer be required. Experience with the alum dosing system at other installations suggests that the typical O&M cost is $15,000 per year. This will constitute a savings for this ECM:

Existing PRS O&M savings = $15,000 per year

In total, the O&M cost to TMWRF for this ECM is:

Total O&M cost = New labor cost + General maintenance cost – Existing PRS O&M savings

Total O&M cost = $32,000 + $22,000 - $15,000 = $39,000 per year

> Savings Interactions

Biosolids reduction in this ECM will affect the biosolids savings calculation in ECM 6. To avoid double counting the savings, we have subtracted from ECM 6 the biosolids reduction that has already been accounted for in this ECM in the savings calculations.

> Stipulated Savings

In the previous calculations, it was determined that the Pearl process will reduce biosolids generated by 5.33 percent. This is a theoretical derivation based on chemical balance and historical process data. However, Ostara reported that at the Durham Advanced Waste Water Treatment Facility (Durham AWWTF) in Tigard, Oregon observed a 15.1 percent total reduction in biosolids after Pearl process installation. Figure 4.5 shows a chart of the average daily biosolids production at the plant after the Pearl process was installed in 2008.

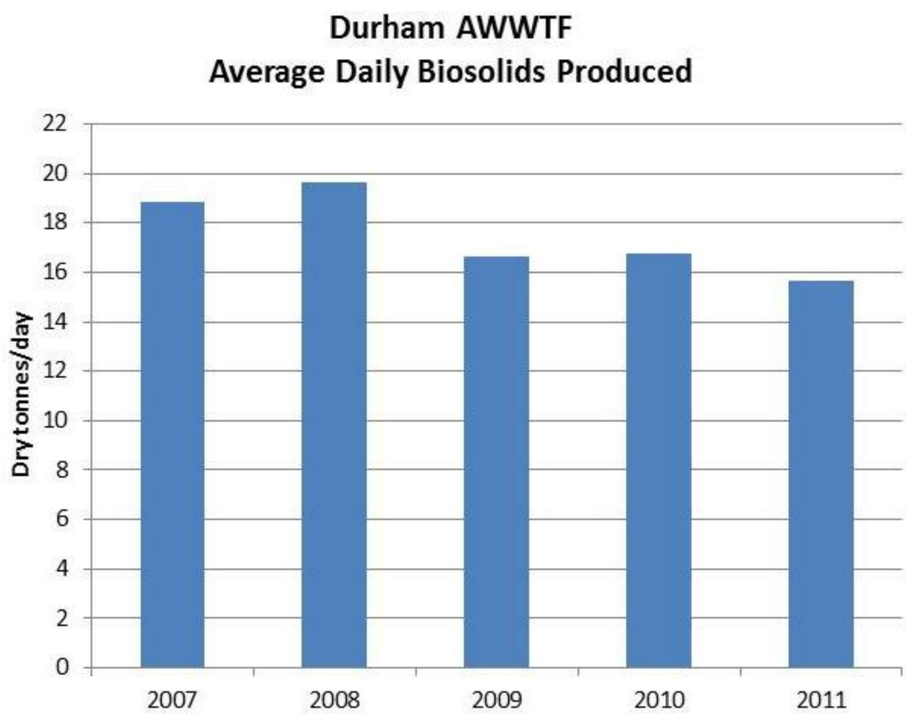


Figure 4.5. Daily Biosolids Production at Durham AWWTF

The substantially higher biosolids reduction above the theoretical estimation can be attributed to several factors not included in the calculations.

- Inert chemical sludge not only contributes its own mass to overall sludge production, it also acts as a “dead weight” in anaerobic digestion. Digestion converts volatile organic material to biogas. Inert chemical sludge therefore reduces digestion performance as digester capacity is occupied with unreactive material. Reducing digestion performance means less organic material is converted to biogas, hence more sludge is produced and less gas is available for energy recovery.
- Reducing the load of phosphorus returned in centrate and consistently returning a lower load improves secondary treatment efficiency and operational flexibility. This results in the secondary treatment process producing less sludge because the lower load means less activated sludge is produced and operating conditions (primarily sludge age) can be adjusted to reduce sludge production.

Because of these indirect interactive effects, it is possible that TMWRF will also realize a reduction in biosolids higher than the project 5.33 percent. However, because the actual numerical amount of the reduction cannot be calculated with 100 percent confidence, Ameresco cannot guarantee this additional increase.

After consulting with TMWRF, the cash flow includes stipulated savings based on the assumption that the reduction in biosolids will be higher than the base calculation. Because this savings is stipulated, it is not part of Ameresco's saving guarantee.

The stipulated savings is calculated assuming that the biosolids will be reduced by an additional 5.33 percent above the base savings calculations. The savings is comprised of hauling cost, disposal cost, and polymer cost savings. The following is a summary of the additional savings. The stipulated savings is the same as previous calculations because the percent of biosolids reduction (5.33 percent) is the same as in previous calculations.

Stipulated hauling cost savings = $10,789 per year

Stipulated disposal cost savings = $28,901 per year

Stipulated polymer cost savings = $56,750 per year

Total stipulated savings = $96,440 per year

4.2.6 References

Data obtained from the TMWRF:

- Architectural, mechanical, and electrical drawings
- Electricity and chemical bills
- Centrate pumps performance data
- Historical data of existing PRS
- Historical data of centrate water composition
- Ostara Nutrient Recovery Technologies, Inc. *Struvite Recovery at the Truckee Meadows Water Reclamation Facility*. January 28, 2008.

General data:

- Field notes and photos
- Report of average daily biosolids production at Durham Advanced Waste Water Treatment Facility in Tigard, Oregon

4.2.7 Utility Interruptions

Ameresco does not anticipate utility interruptions during the installation of the Pearl process. The new building will be isolated from the rest of the plant. All new equipment inside the building can be installed separately from the existing process. The only time the installation will interface with the existing system is for utility tie-ins to the new building. However, with proper isolations and coordination, we do not expect any interruption for this work.

4.2.8 Other

> Equipment Service Life

The Pearl process is a very robust system with minimal maintenance requirements. The reactor is an enclosed vessel with no moving parts. Furthermore, neither the classifying screens nor silos have moving parts. The bagging system has a manually-operated gate. Other ancillary equipment (e.g., recirculation pumps) are stock (i.e., non-specialized) products with standard service lives.

Equipment service life for the major components is as follows:

- Pearl 2000 reactor: Greater than 15 years
- Classifying screens, silos, and bagging system: Greater than 15 years with proper cleaning
- Fluidized bed dryer system: 15 years

> Compatibility with Existing Systems

The Pearl process will replace the existing PRS at the plant. Phosphorous and ammonia concentration from the process effluent will be lower and more stable than produced by the existing PRS. Consequently, no compatibility issues integrating the Pearl process to the main treatment process train are anticipated. In fact, the main process will benefit from the lower and more stable chemical composition of the returning centrate.

4.3 ECM 4A: Biogas Cogeneration System

4.3.1 Overview

This ECM proposes the implementation of a new cogeneration (cogen) system that uses biogas produced in the anaerobic digesters to generate power. Waste heat would also be recovered from the system for multiple uses in the plant. The existing cogen system is no longer in service due to operation and maintenance issues, in addition to limitations on the quality and quantity of digester gas produced. As part of this ECM, the existing system will be upgraded with a new and more efficient engine.

4.3.2 Recommendations

Ameresco recommends replacing the existing non-functional biogas cogen system with a new system that uses the excess digester gas produced during the treatment process. Generating electricity and heat using excess digester gas will reduce electricity costs at the plant. It will also help TMWRF meet or exceed environmental regulations as compared to the existing practice of flaring the excess gas. Figure 4.6 depicts the basic flow diagram of the proposed cogeneration system. A digester gas cleaning system is not included in the scope because TMWRF will install the system separately.

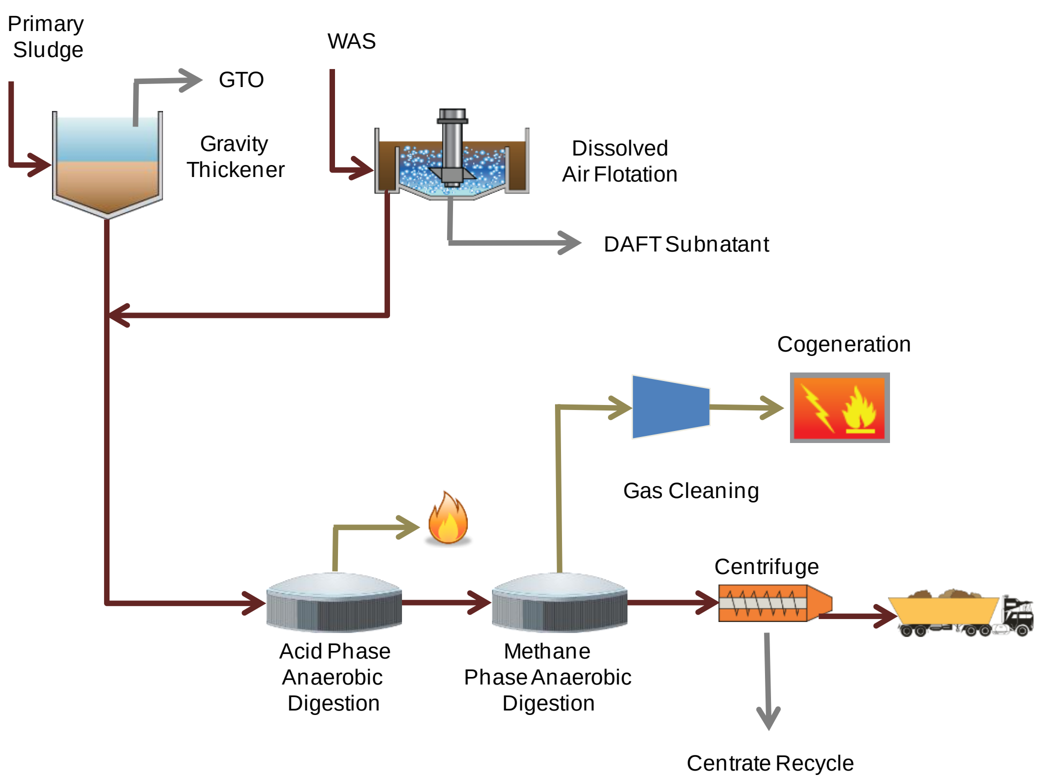


Figure 4.6. Basic Process Flow Diagram for the Biogas Cogeneration System

The new cogeneration system will consist of a new generator fueled by digester gas, along with heat exchangers to capture heat from the engine's jacket and exhaust. The engine will turn a generator that will produce three phase, 60 Hz, and electricity at 480 V, which will be stepped up to 2,400 V for connection to the main switchgear in the electrical building across the street. This is the same electrical point of connection as the existing cogeneration system. Waste heat from the engine will be captured via heat exchangers and connected to the plant's existing hot water loop.

Ameresco proposes to install one Jenbacher JMS320C81 engine for the system with a design electrical output of 850 kW and thermal output of 1,854 MBtu/hr. The design electrical and thermal output requires a constant digester gas flow rate of 13,876 cft/hr with a heating value of 550 Btu/cft. Table 4.7 summarizes the design parameters for the new cogeneration system.

Table 4.7. Design Parameters for the New Cogeneration System

Parameter	Design Value
Cogeneration Engine	Jenbacher JMS320C81
Electrical Output	850 kW @ 480V, 3 Ph, 60 Hz
Thermal Output	1,854,000 Btu/hr
Engine Digester Gas Flow Rate	13,876 cft/hr
Total Digester Gas Flow Rate	29,333 cft/hr
Digester Gas Heating Value	550 Btu/cft
Cogeneration Engine	Jenbacher JMS320C81

The cogeneration system is designed to be operated in conjunction with existing boilers at the plant. Digester gas produced from the digesters will be treated at the gas cleaning system and then sent to the engine for electricity and heat production. Digester gas not used at the cogen engine will be used in the existing boilers to generate heat. Based on the amount of gas produced at TMWRF, it is anticipated that all gas will be used in the winter months to meet the heating demand of the plant. However, we anticipate that not all the digester gas produced will be used in summer months when the heat demand is low, and some amount will still need to be flared. Table 4.8 shows a comparison between heat demand at TMWRF and the design heat production of the cogen system and boilers. The heat demand profile is calculated based on the metered digester gas used at sludge boilers one thru five, and the boilers at the Chemical Building.

During development of this ECM, Ameresco considered installing a second cogen engine to utilize the excess digester gas available in the summer months. However, because the second engine will not operate continuously, the economics are not attractive. Consequently, Ameresco recommends installing only one cogen engine in this project. TMWRF may reconsider installing the second engine in the future once the condition is more favorable (e.g. higher electricity rate, increased digester gas production, or available capital funds).

Table 4.8. Baseline Heat Load at TMWRF and Design Heat Production

Month	Baseline Heat Load (MMBtu/hr)	Design Engine Heat Output (MMBtu/hr)	Design Boilers Heat Output (MMBtu/hr)	Total Design Heat Output (MMBtu/hr)
January	8.7	1.85	7.23	9.08
February	9.0	1.85	7.23	9.08
March	8.6	1.85	7.23	9.08
April	7.6	1.85	7.23	9.08
May	6.2	1.85	7.23	9.08
June	5.0	1.85	7.23	9.08
July	4.1	1.85	7.23	9.08
August	4.1	1.85	7.23	9.08
September	3.3	1.85	7.23	9.08
October	4.3	1.85	7.23	9.08
November	5.9	1.85	7.23	9.08
December	7.1	1.85	7.23	9.08

4.3.3 Scope of Work

The following is a summary of the scope of work for this ECM. Preliminary design diagrams for the new cogeneration system are provided in the Appendix E, including diagrams for electrical connections and hot water capture for the system. A full engineering design will be done prior to construction. Construction drawings stamped by a Nevada PE and specifications for the work will be provided before construction.

> Structural

- Demolition of the existing cogeneration engine and heat capture system. Existing digester gas pipe system will remain.
- Saw cut existing slab and place 3 foot thick foundation pad for the new cogeneration engine.
- Assume no existing utilities will interfere with the new foundation. None are shown on the as-built drawings.
- Assume sub grade is suitable for new foundation (i.e., no cover excavation).

> Mechanical

- Remove and replace one existing Caterpillar cogen engine with a new Jenbacher JMS320C81 cogen engine.
- Existing cogen unit and associated switchgear and MCC to be turned over to Owner.
- Digester gas conditioning system is not included in the scope because TMWRF will install the system separately.

- Install new waste heat capture system for the cogeneration engine per manufacturer's specifications.
- Install two new pumps and pipes for the hot water system.

> Electrical

- Electrically disconnect the existing cogeneration engine for removal and haul-off. Demolish the existing electrical gear.
- Install new switchgear, a new MCC, cable tray, conduit, and wiring for the new cogeneration engine.
- Install all electrical connections for the new cogeneration engine.
- Furnish and install one 2,000 kVA, 480 V to 2,400 V, transformer outside the building. Furnish a transformer pad for installation.
- Install 90 linear feet of 3 foot by 2 foot of concrete encased duct bank with one foot of cover. The new duct bank will run from the newly installed transformer to the existing hand hole EHH-P11 in front of the cogeneration building.
- Install electrical wiring from hand hole EHH-P11 to the main electrical switchgear building via existing underground conduits. Replacement of underground conduits is not included.
- Terminate new cogeneration engine conductors to the existing 2,400 V switchgear in the main electrical building. It is assumed that the main switchgear will be ready for the termination.
- Install electrical connections for the new hot water pumps.
- Start-up and commissioning of the cogeneration engine and switchgear will be performed with manufacturer's technician/engineer.

> HVAC

- Install a new exhaust fan for the engine room and install electrical connections.
- Recommission the existing louvers and dampers to ensure adequate fresh air supply for the cogeneration engine.

4.3.4 Baselines and Assumptions

The following baselines and assumptions were made in the development of this ECM:

- Ameresco plans to use one Jenbacher JMS320C81 engine for the system with design electrical output of 850 kW and thermal output of 1.85 MMBtu/hr.
- The design electrical and thermal output requires a constant 13,876 cft/hr of digester gas with a heating value of 550 Btu/cft. Ameresco assumes that TMWRF will provide this amount of gas consistently to the engine at no charge.
- Ameresco assumes that the digester gas supplied to the cogen engine meets the fuel quality requirement as specified by the engine manufacturer. Table 4.9 lists the general limiting conditions for the fuel. Complete details of the requirement are listed in the technical document TA1000-0300 included in Appendix E.

Table 4.9. General Limiting Condition for the Cogen Engine Fuel

Requirement	Values
Gas Pressure[1]	
Gas Pressure, Max Fluctuation Rate	10 mbar/sec
Gas Temperature	0°C < T < 40°C
Gas-Moisture Content[2]	< 80% relative
Condensate, Sublimate[3]	0
Humidity Fluctuation Rate	1% / 30 sec
Methane Value Fluctuation Rate	10 MN / 30 sec
Oxygen Content[4]	< 3% volume

Notes:

1. *In accordance with project specifications.*
2. *There must be no condensate in the gas train up to the gas mixer.*
3. *No condensate or sublimate in the components that come into contact with gas and/or mixture.*
4. *When using a TSA gas cleaning system.*

- Digester gas cleaning system is not included in this scope. TMWRF informed Ameresco that the gas cleaning system will be installed separately. Ameresco assumes that the cleaning system is installed and operational by the time construction is completed and the engine is ready for operation.
- TMWRF will be responsible for operating and maintaining the cogeneration system per design specifications throughout the performance period. The cogen engine requires periodic maintenance as specified by manufacturer. O&M documents for the engine are provided in Appendix E. The project cash flow includes an annual cash stream to pay for the periodic maintenance.

- Ameresco assumes that the main switchgear is ready for terminal connection from the cogen engine. During scope development, TMWRF was in the process of replacing the main switchgear where the existing cogen system is connected. Ameresco assumes that after replacement, a breaker will be available for the new cogen engine; therefore, and the connection can be completed without modification to the main switchgear.
- Ameresco plans to install new conductors in the existing underground conduit from electrical hand hole EHH-P11 to the main electrical building. From the available electrical drawings, there is space in the conduit for additional conductors. We assume that this condition is valid and that the underground conduit is in good condition.

4.3.5 Detailed Energy Analysis

The new cogeneration system will generate electricity at TMWRF and reduces the annual electricity cost. The system will also produce hot water for plant use; however, there is no monetary savings for the hot water because TMWRF is already using the free digester gas to provide heat to the plant. There is an annual operations and maintenance cost for the system. This is included in the savings calculation because it will be an incremental effort/expense to TMWRF.

Table 4.10 shows a summary of cost savings for this ECM.

Table 4.10. Summary of Cost Savings for ECM 4A

Source	Savings ($)	Additional Costs (S)
Electricity Generation	343,233	
O&M Costs		127,719
Total Net Savings	**$215,514**	

> Energy Savings

Design electrical output of the engine is 850 kW. However, a 90 percent net output ratio to account for losses at the switchgear, transformer, and conductors has been assumed in the calculations. Using this output ratio, the projected net electrical output is:

Net electrical output = Design electrical output x Net output ratio

Net electrical output = 850 kW x 90%

Net electrical output = 765 kW

For maximum benefit, the engine should be operated continuously. In practice, however, there will be down time from regular maintenance activities, such as oil change, filter change, belt replacement, etc. Maintenance work for the gas cleaning system will also require engine shut down. From our experience operating and maintaining a cogeneration system at other sites, the average system uptime is 85 percent. The projected monthly electricity production of the engine is then:

Month electricity = Net electrical output x Hours in month x Uptime %

Month electricity = 765 kW x Hours in month x 85%

Table 4.33 lists the projected monthly electricity production for the engine. In total, the annual electricity production is projected to be 5,696,190 kWh. There is no peak demand savings anticipated for this ECM because the engine will not operate continuously.

Monetary savings from the electricity production is calculated based on the time-of-use rate for the GS-3 service (reference Section 3.1.1). The electricity production is assumed to be evenly distributed throughout the on-peak, mid-peak, and off-peak periods in the savings calculations.

Winter On-peak kWh = Month electricity x (4 hr/24 hr)

Winter Mid-peak kWh = Month electricity x (10 hr/24 hr)

Winter Off-peak kWh = Month electricity x (10 hr/24 hr)

Summer On-peak kWh = Month electricity x (5 hr/24 hr) x (5 days / 7 days)

Summer Mid-peak kWh = Month electricity x (6 hr/24 hr) x (5 days / 7 days)

Summer Off-peak kWh = Month electricity x { (13 hr/24 hr) x (5 days/7 days) + (2 days/7 days) }

Detailed calculations for the dollar cost savings is provided in Appendix E. The projected monthly dollar savings is listed in Table 4.11. In total, the annual electricity cost savings is projected to be $343,233.

Table 4.11. Projected Monthly Electricity Production and Savings for the Cogen System

Month	Days per Month	Monthly Production (kWh)	Monthly Savings (S)
January	31	483,786	27,510
February	28	436,968	24,847
March	31	483,786	27,510
April	30	468,180	26,622
May	31	483,786	27,510
June	30	468,180	26,622
July	31	483,786	34,023
August	31	483,786	34,023
September	30	468,180	32,925
October	31	483,786	27,510
November	30	468,180	26,622
December	31	483,786	27,510
	Total Savings	**5,696,190**	**$343,233**

> Maintenance Costs

The cogen engine requires regular maintenance per manufacturer's specifications. Table 4.12 shows a summary of the maintenance requirements for the engine. Detailed operation and maintenance requirements for the engine are provided in a technical document from the manufacturer, which is included Appendix E. Because the O&M costs will be an additional burden to TMWRF, Ameresco has allocated the money to perform the O&M in the annual cash flow. This allocation effectively reduces the projected $343,233 annual savings from electricity use reduction.

Throughout the performance period, TMWRF will be responsible for operating the cogen system. Because the system will be automated, daily operations will consists mainly of monitoring the working parameters and visual checks of the engine to confirm remote readings. We anticipate TMWRF will not need more than one hour per day for operation. The projected annual operation cost is then:

Annual operations cost = 1 hr/day x 365 days/yr x $40/hr

Annual operations cost = $14,600 / yr

For the preventive maintenance (PM) required at every 2,000 operation hour (oph), TMWRF will provide the labor for the maintenance with parts purchased from the manufacturer's local vendor. The cost for this maintenance consists of $1,600 in parts and $800 in labor, assuming 20 hours of labor at $40/hr. Previous calculations project that the engine will run 7,466 hours per year. Since the PM is needed every 2,000 oph, the cost has been annualized as follows:

PM frequency per year = 7,466 run hours / 2,000 oph

PM frequency per year = 3.7

The annualized PM cost is then:

Annualized PM cost = PM frequency per year x Cost per PM

Annualized PM cost = 3.7 x $2,400

Annualized PM cost = $8,935

TMWRF will hire the engine manufacturer's local vendor to perform the routine maintenance (RM) at every 10,000 oph. The cost for this maintenance is $8.58/oph, or when annualized:

Annual RM cost = Unit RM cost x Annual run time

Annual RM cost = $8.58/oph x 7,466 hrs/yr

Annual RM cost = $63,887

A major overhaul of the engine is required every 60,000 operational hours at a cost of $324,714. TMWRF will also hire the manufacturer's local vendor to perform this work. Annualizing the cost for this overhaul based on the annual run hours yield an annual cost of $40,297.

Annual overhaul cost = (7,466 hrs/yr / 60,000 oph) x $324,714

Annual overhaul cost = $40,297

The total projected annual cost for O&M for this ECM is then:

Total O&M cost = Annual operation cost + Annual PM cost + Annual RM cost + Annual overhaul cost

Total O&M cost = $14,600 + $8,935 + $63,887 + $40,297

Total O&M cost = $127,719

Table 4.12. Summary of Maintenance Requirements for ECM 4A

Maintenance	Frequency	O&M Costs[1] ($)
Preventative Maintenance (PM)	Every 2,000 oph	Parts $1,600 Labor 20 hours
Ignition and Sparks Plugs		
Valve Clearances		
Engine Air Intake and Filter Cloth		
Leak Tests		
Control Rod Assembly		
Gas Pressure Control System		
Crankcase Ventilation		
Routine Maintenance (RM)	Every 10,000 oph	Unit cost = $8.58 / oph Total cost = $85,800
All Items on the PM List		
Replace Starter		
Vibration Damper		
Mixture Bypass Valve		
Piston/Piston Cooling		
Cylinder Liner/Scraper Ring		
Camshaft/Control System		
Major Overhaul	Every 60,000 oph	One-time cost: $324, 714

Notes:

1. Costs included in project.

> Savings Interactions

There are no savings interactions between this ECM and others. Implementing ECM 4A can potentially increase gas production at the digesters. However, the savings calculated for this ECM does not depend on that production increase.

4.3.6 References

Data obtained from TMWRF:

- Architectural, mechanical and electrical drawings
- Electricity bills
- Monthly digester gas production meter data

Other data:

- Field notes and photos
- GE Jenbacher Technical Description TS JMS 320 CS81 480v 24JUN2013
- GE Jenbacher Technical Document TI 1000-0300
- GE Jenbacher O&M Technical Documents

4.3.7 Utility Interruptions

Ameresco does not anticipate utility interruptions in performing the work because the cogen system can be isolated. The existing engine will no longer be in use and can be demolished with no interruption to the plant's operation. Existing heat exchangers and hot water pumps can be isolated from the plant's hot water loop. We anticipate a breaker is available at the main switchgear for connection to the cogen system; therefore, the connection can be made without shutting down the main switchgear.

4.3.8 Other

> Equipment Service Life

The equipment service life for the major components is as follows:

- Jenbacher JMS320C81 Engine: 60,000 operational hours until major overhaul

> Compatibility with Existing Systems

Ameresco does not anticipate compatibility issues in implementing this ECM. The new cogen engine will generate three-phase, 60 Hz electricity at 480 V that will then be stepped up to 2,400 V for connection to the main switchgear. The cogen system will have a power control module that will match the quality of electricity generated with grid electricity. Waste heat captured from the engine will be used to add heat to the existing hot water loop.

4.4 ECM 4B: Digester Domes Rehabilitation

4.4.1 Overview

The biosolids digestion process at TMWRF is a two-phase system that includes one acid phase (AP) digester and five methane phase digesters. During the energy audit, only methane digesters 1, 2, 4, and 5 were in use; moreover, digester 2 was in operation as a holding tank. Digester 3 is out of service due to corrosion and leakage from the cover. According to TMWRF staff, digesters 1 and 2 also have issues with corrosion and leakage at the covers.

Figure 4.7. TMWRF Biosolids Digestion Facility

Prior to the energy audit, TMWRF had contracted Brown and Caldwell to perform a condition assessment and evaluation of the digester 3 cover. Study results show that repairs are needed for the cover to address the corrosion and leakage problems. TMWRF has informed Ameresco that the 5 year Capital Improvement Plan (CIP) already includes plans to repair and rehabilitate the digester 3 cover.

4.4.2 Recommendations

Under the scope of this project, Ameresco recommends repairing the cover of digester 3 as recommended in Brown and Caldwell's study. Repairing this cover will improve plant safety by eliminating digester gas leakage and prevent corrosion at the nearby main electrical switchgears. According to TMWRF, this gas leakage is one reason for the electrical system failure at the main switchgears in October 2012. Repairing the cover will also improve sludge digestion performance and increase the amount of digester gas produced. Increasing the digester gas produced will also help increase the electricity output from the cogeneration engine installed under the scope of ECM 4A.

Ameresco also recommends repairing the cover for digester 1 in addition to 3 to ensure there is no digester gas leakage from digester 1. Originally, Ameresco had proposed to repair the cover for digester 2, as well, because TMWRF reported it to be faulty. However, because this ECM is a capital improvement with negligible savings, Ameresco recommends TMWRF not include the digester 2 cover in this project to minimize upfront capital costs.

At the time of this writing, TMWRF is operating below its design capacity (31 MGD influent flow with maximum capacity of 44 MGD). This below-capacity operation is consistent with the observed operation of the digesters where TMWRF uses only four out of five methane digesters. Furthermore, digester 2 is being used as a holding tank. Therefore, TMWRF only needs three methane digesters for current operation. Repairing digesters 1 and 3 covers will still allow TMWRF four operational methane digesters for current plant load. Nevertheless, Ameresco recommends repairing the digester 2 cover as soon as capital funds are available or as plant load requires.

4.4.3 Scope of Work

The scope of work for the digester cover repairs are based on the detailed recommendations from Brown and Caldwell's Technical Memorandum, *Digester No. 3 Cover Evaluation* (May 3, 2012). The following is a summary of the scope. Reference Appendix F for the full technical memorandum.

- **Digester roof replacement:** Partial repair and replacement of polyurethane foam (PUF) coating on the top side of the digester cover.
- **Interior coating of digester cover:** 100 percent solids elastomer polyurethane coating of underside of dome and interior skirt plate; spring/summer application.
- **Annular space seal:** Install two-layer gas membrane attached to packing support angle and the cover skirt plate.
- **Emergency overflow system:** Install an emergency overflow pipe, including a dual gas trap emergency overflow assembly.
- **Exterior gunite repair:** Repair cracks in the gunite on the digester gallery area.

4.4.4 Baselines and Assumptions

The following baselines and assumptions were made in the development of this ECM:

- Scopes of work for this ECM include the recommendations detailed in Brown and Caldwell's technical memorandum, *Digester No. 3 Cover Evaluation* (May 3, 2012). Any assumed work not identified in the technical memorandum is not included.
- Brown and Caldwell's condition assessment study was performed for digester 3 cover only. Ameresco assumes that the condition of the digester 1 cover is similar and the scope of work recommended by Brown and Caldwell for the digester 3 cover also applies to 1. Ameresco has consulted with TMWRF regarding this assumption, and TMWRF agreed that this is a fair assumption because the two digesters are of similar construction, operational uses, and age.
- Prior to repairing the digester 1 cover, Ameresco plans to hire Brown and Caldwell to do a condition assessment study for the digester 1 cover. Results from this detailed study will be used to repair the digester 1 cover.
- Based on Brown and Caldwell's study, Ameresco assumes that the steel cover is structurally competent and it can be put back in service. Complete replacement of the covers is outside the scope of this ECM.
- Ameresco plans to clean the digesters prior to repair. According to TMWRF, digester 3 has been emptied and cleaned. Ameresco assumes it is still in that condition when work commences. For digester 1, Ameresco assumes that TMWRF will transfer sludge from the digester prior to cleaning, leaving a maximum sludge depth of eight feet.
- Ameresco assumes no repair or replacement due to existing damage or corrosion of metal roofing and support rafters, and all digester metals, digester concrete, pipe, and equipment.
- Ameresco assumes the steel cover plate is still seal welded to the support rafters and no remedial work (e.g., welding or caulking) is required prior to coating.
- Ameresco assumes the stainless steel clamp bar is installed in 10 foot sections and not welded.

4.4.5 Detailed Energy Analysis

> Energy Savings

This ECM is capital repair work; therefore, no energy savings are projected.

> Maintenance Savings

There is no maintenance savings from this ECM.

4.4.6 Savings Interactions

Repairing the digester covers will increase digester gas production by reducing leakage and improving digestion performance. This will allow TMWRF to use the additional digester gas produced at the cogeneration engine to generate more electricity and heat for plant use (see Section 4.3). However, Ameresco does not include this interactive savings because the increase in digester gas cannot be quantified with certainty until the repairs are actually completed.

4.4.7 References

Data obtained from TMWRF:

- Brown and Caldwell. *Technical Memorandum: Digester No. 3 Cover Evaluation*. May 3, 2012.
- Architectural, mechanical, and electrical drawings

General data

- Field notes and photos

4.4.8 Utility Interruptions

Ameresco does not anticipate any interruptions to plant operations to complete the repair work. Digester 3 is currently out of service. Once the repair on the digester 3 cover has been completed, Ameresco will coordinate with TMWRF to transfer the sludge from digester 1 to 3, and shift operations to digester 3. After repairs to the digester 1 cover are complete, Ameresco recommends TMWRF remove digester 2 from service and use digester 1 for operation instead.

4.4.9 Other

> Equipment Service Life

n/a

> Compatibility with Existing Systems

Ameresco does not anticipate any compatibility issues in repairing the digester covers.

4.5 ECM 6: Dewatering System Upgrade

4.5.1 Overview

The existing Solids Dewatering Facility at TMWRF consists of dewatering feed pumps, dewatering centrifuges, dewatering polymer, cake pumps, and dewatered cake storage hoppers. Most of this equipment has been in service for several years and is now outdated. The purpose of this ECM is to implement improvements to the facility as necessary to simplify operations, minimize required maintenance, increase the life of the dewatering facility, and improve dewatering performance to result in O&M cost savings.

4.5.2 Recommendations

Ameresco recommends upgrading the Solids Dewatering Facility in addition to the near-term improvements proposed in ECM 9 (reference Section 4.7). The existing centrifuges will be demolished and replaced with new, more efficient centrifuges. Existing dewatered cake piston pumps require extensive maintenance and will be replaced with new cake pumps. Existing cake discharge pipes cannot handle the required cake discharge pressures to pump drier cake and thus will be replaced. The existing liquid polymer system for sludge dewatering is manual and will be replaced with a new automated system.

Cost savings for this upgrade is primarily due to a higher cake solid content, which reduces the amount of biosolids generated. This, in turn, will reduce the cost of hauling and disposing the biosolids to the landfill. Additional cost savings will also be realized from reduced equipment power usage.

Currently, TMWRF has three centrifuges and three cake pumps for dewatering and conveying the sludge. However, TMWRF only uses one centrifuge and one cake pump most of the time, as the equipment has the capacity to handle all of the sludge produced from the process. Very rarely, TMWRF operates two centrifuges and two cake pumps for dewatering, most often during the transition period when TMWRF switches from one centrifuge to another for equipment rotation. As such, TMWRF has two centrifuges and two cake pumps on stand-by at any one time.

Because TMWRF does not need the third centrifuge and cake pump except for backup, Ameresco recommends replacing only two centrifuges and two cake pumps in this ECM to save upfront construction costs. The third existing centrifuge and cake pump will remain in operation as a backup, although it is not anticipated that TMWRF will ever use them. Nevertheless, cake discharge pipes for all centrifuges and cake pumps will be replaced with larger pipes that can handle the higher pressure of the drier cake. Should TMWRF ever need another centrifuge and cake pump in operation continuously to handle the sludge, the third centrifuge and cake pump could be replaced so that the facility still has full system redundancy.

4.5.3 Scope of Work

The following is a summary of the scope of work for this ECM. A full engineering design will be done prior to construction. Construction drawings stamped by Nevada PE and specifications for the work will be submitted before construction.

> Structural

- The existing centrifuge and cake pump structure and foundations pads are assumed to be suitable for the new equipment. Only minor structural modifications are assumed in order to fit new equipment in the building (e.g., enlarge equipment pads).

> Mechanical

- Ameresco plans to replace two existing centrifuges with two new Alfa-Laval G2 centrifuges. Manufacturer's cut sheets for the new equipment are provided in the Appendix G.
- Ameresco plans to replace two existing cake pumps with two new Schwing Bioset cake pumps. Manufacturer's cut sheets for the new equipment are provided in the Appendix G.
- Scope of work includes removing and replacing two existing centrifuges with two new centrifuges. One existing centrifuge and associated existing cake pump will remain in place and operable.
- Remove and replace two existing cake pumps with two new cake pumps.
- Remove and replace all cake pump discharge piping (including pipe on top of silos), associated valves, valve actuators, and appurtenances.
- Install three new polymer lube ring systems at the cake pump discharge piping. Ameresco assumes that existing plant polymer system is suitable to feed the lubrication rings.
- Sludge feed pump refurbishment or replacement is not included.
- Sludge feed system, polymer feed system, and wash water system are not included in this ECM.
- Existing centrate pipe is planned to be reused. No centrate pipe replacement is included in this ECM.
- This ECM does not include refurbishment or work on the existing cake silos. This work is included in ECM 9.

> Electrical and Instrumentation

- Ameresco plans to reuse existing cake discharge piping instrumentation.
- Ameresco will furnish two new MCCs to replace MCCs 13 and 14 in the Solids Dewatering Facility. The new MCCs will have the same ampere interrupting capacity (AIC) ratings as existing MCCs.

- Remove and replace MCCs 13 and 14 and the electrical connections for the two existing centrifuges and cake pumps. One existing set to remain operational. Conduit and wire size is based on the 60 HP Alfa-Laval G2 centrifuges.
- Install control panels, VFDs, starters, control devices, instrumentation, and other requirement components for the centrifuges as provided by manufacturer. Install control panels and the conduit and wiring to tie the equipment together. Perform startup, programming, instrument calibration, etc. with centrifuge supplier and electrical contractor.
- Install communication conduit and cabling from the new centrifuge PLC/equipment to the plant's existing distributed control system (DCS) panel in the Dewatering Facility. Programming of the centrifuges will be by manufacturer. Programing of the plant's DCS will be by Owner.
- Install conduit and wiring to connect new cake pumps to the plant's DCS and MCC. Install connection between the new cake pumps control panel and any field devices in the Dewatering Facility.
- Programming for the new cake pumps will be by manufacturer. Programming for the plant's DCS will be by Owner.
- Electrical work for the building's HVAC system is not included in this ECM. Rather, it is included in the scope of work for ECM 9.

4.5.4 Baselines and Assumptions

Preliminary design of the new centrifuges, cake pumps, and cake discharge piping are based on the following baseline design parameters. These parameters show the design capacity of the plant since the last expansion in 2005, as well as the actual operation of the plant during the audit as collected from the SCADA system. The upgrades recommended in this ECM are sized based on the design capacity of the plant, which is projected to be still valid at the end of the 15 year performance period. However, the energy savings calculation is based on the actual operation of the plant in 2012.

The following data and assumptions were used in the development and savings calculation of this ECM:

- In accordance with the SCADA trend data, Ameresco determined that TMWRF only uses one centrifuge and one cake pump for dewatering, which operate continuously.
- The average sludge feed flow rate to the centrifuge is 140.11 GPM.
- The average solids content in the existing biosolids produced is 15.6 percent by weight, or a wet-to-dry content ratio of 6.41:1.
- The average biosolids production at TMWRF is 46,435 wet tons per year according to the landfill invoices from Waste Management.

- The average tonnage of biosolids removed per pick-up is 23 tons according to the invoices from Western NV Transport. We assume that after the biosolids reduction, the company will haul the same amount per pick-up.
- The savings calculations use $99.90 per pick up for hauling cost and $11.68 per ton for landfill disposal cost. These unit costs are based on 2012-2013 costs for the services. Reference Section 3.5 for more details about hauling and waste disposal costs.
- Ameresco assumes that the maintenance cost for the new equipment will remain the same as before the retrofit, and TMWRF will be responsible for maintaining the new equipment. Because the retrofit proposes using the same technology as existing (i.e., centrifuge for water-solid separation and cake pump for biosolids conveyance to the hopper silos), Ameresco does not anticipate additional maintenance responsibility to TMWRF after the retrofit.

Table 4.13. Baseline Design Parameters for the Solids Dewatering Facility

Parameter	Unit	Actual Operation	Design Capacity
Flow			
Average Daily Maximum Month (ADMM)	mgd	31	44
Sludge Production			
Thickened Primary Sludge	gpm	101	130
Thickened Waste Activated Sludge	gpm	49.1	63.3
Digested Sludge Dewatering Feed	gpm	169	218
Digested Sludge Solids Concentration	%	2	2
Digested Solids Production	lbs/day	40,595	52,365
Dewatering Feed			
Type of Unit	n/a	feed pumps	feed pumps
Number of Units	quantity	3	3
Existing Pump Capacity	gpm	162	162
Sludge Dewatering			
Type	n/a	centrifuges	centrifuges
Number of Units	quantity	3	3
Unit Hydraulic Capacity	gpm	100 - 175	100 – 175
Minimum Solids Capture	%	95	95
Dewatered Cake			
Cake Production	lbs/day	38,570	49,750
Solids Concentration	%	15.6	20 – 24
Dewatered Cake Storage			
Type of Unit	n/a	hopper silos	hopper silos
Number of Hoppers	quantity	4	4
Hopper Capacity	ft^3	3,500	3,500

4.5.5 Detailed Energy Analysis

Implementing the recommended improvements under the scope of this ECM will reduce biosolids production, which will lower the biosolids hauling and disposal costs. In addition, there will be some electricity savings from reduced power consumption for the new centrifuges and cake pumps.

Table 4.14 provides the summary of cost savings for ECM 6.

Table 4.14. Summary of Cost Savings for ECM 6

Source	Savings ($)	Additional Costs (S)
Hauling Cost Savings	52,448	
Disposal Cost Savings	140,963	
Electricity Demand Savings	1,637	
Electricity Energy Savings	5,907	
Total Net Savings	**$200,955**	

> Biosolids Savings

Baseline annual biosolids production at the facility is 46,435 tons per year. This is the wet ton that is hauled and disposed of at the landfill. ECM 2 will also reduce biosolids production via the Pearl process. To account for this interaction, we performed a baseline adjustment for ECM 6.

Adjusted baseline = Annual baseline – ECM 2 biosolids reduction

Adjusted baseline = 46,435 tons/yr – 4,949 tons/yr

Adjusted baseline = 41,486 tons/yr

The biosolids produced is a wet water-solid mixture with a solid content of 15.6 percent. The wet-dry ratio of the existing biosolids is as shown below. This ratio means that one pound of dry solid is equivalent to 6.41 lbs of wet biosolids.

Existing wet-dry ratio = 1 / 15.6% = 6.41

From manufacturer's specifications, the new centrifuge can produce biosolids with a solid content in the range of 20 - 24 percent. The calculations use 22 percent as the post-retrofit biosolid content. The wet-dry ratio of the new biosolids is then projected to be:

New wet-dry ration = 1 / 22% = 4.55

After the retrofit, the amount of dry solid that will need to be removed is the same. However, the new centrifuge will remove more water from the mixture, and thus reduce the wet biosolids weight. The reduction of the biosolids weight can be calculated as follows:

% biosolids reduction = (Existing wet-dry ratio – New wet-dry ratio) / (Existing wet-dry ratio)

% biosolids reduction = 1 – (New wet-dry ratio / Existing wet-dry ratio)

% biosolids reduction = 1 – (4.55 / 6.41)

% biosolids reduction = 29%

After the new centrifuge installation, the amount of biosolids produced will be 29 percent lower than the baseline. The annual biosolids savings is then:

Biosolids savings = 29% x Adjusted baseline

Biosolids savings = 12,069 tons/yr

The biosolids savings will reduce the amount of pick-up needed by Western NV Transport to haul the waste to the landfill. The savings attributed to the reduced hauling requirements annually is calculated below. We assume that after the retrofit, the hauling company still fills the truck full at 23 tons per pick-up.

Hauling pick up savings = Biosolids savings / Tonnage per pick up

Hauling pick up savings = 12,069 tons/yr / 23 tons per pick up

Hauling pick up savings = 525 pick up / year

Using $99.90 per pick up cost, the cost savings from fewer hauling pick up is:

Hauling cost savings = 525 pick up/yr x $99.90

Hauling cost savings = $52,448 per year

Landfill cost for final disposal is based on the amount of biosolids dumped at the landfill. The total tipping fee for disposal is $11.68 per ton. Using this unit cost, the projected landfill cost savings is:

Disposal cost savings = 12,069 tons/yr x $11.68 per ton

Disposal cost savings = $140,963 per year

> Electricity Savings

Power consumption of the existing equipment is as follows:

Existing power consumption (HP) = Centrifuge main drive + Centrifuge back drive + Cake Pump

Existing power consumption (HP) = 125 + 15 + 50

Existing power consumption (HP) = 190

Power consumption of the new equipment is as follows:

New power consumption (HP) = Centrifuge main drive + Centrifuge back drive + Cake Pump

New power consumption (HP) = 60 + 15 + 100

New power consumption (HP) = 175

Power consumption savings from the retrofit is then:

Power savings (HP) = 190 – 175 = 15 HP

Power savings (kW) = 15 HP x 0.746 kW/HP

Power savings (kW) = 11.2 kW

From the SCADA trend, only one centrifuge and one cake pump run continuously. Therefore, the projected monthly demand savings from the new equipment is 11.2 kW per month, while the annual electricity savings is:

Annual electricity savings = 11.2 kW x 8,760 hr/yr

Annual electricity savings = 98,024 kWh/yr

The dollar cost savings from the reduced electrical use is calculated based on the time-of-use rate of the service. Reference Appendix G for details of this cost calculation. A summary of the cost savings is shown below:

Annual $ demand savings = $1,637 per year

Annual $ electricity savings = $5,907 per year

> Maintenance Savings

Ameresco does not claim maintenance savings for this ECM. The amount of maintenance needed for the new equipment will be similar to existing equipment, as such there will not be an O&M increase for TMWRF in association with this ECM.

> Savings Interactions

Biosolids reduction in this ECM is affected by the biosolids reduction in ECM 2. To avoid double counting the savings, we have subtracted the biosolids reduction attributed to ECM 2 from ECM 6.

4.5.6 References

Data obtained from TMWRF:

- Architectural, mechanical, and electrical drawings

- Electricity, biosolids hauling, and biosolids disposal bills
- SCADA data for dewatering facility operations

General data:

- Field notes and photos

4.5.7 Utility Interruptions

Work inside the Solids Dewatering Facility will require a shutdown of approximately two months. For this shutdown period, Ameresco plans to install a temporary dewatering system outside the facility to handle the sludge produced from plant process. Using the temporary dewatering system, Ameresco does not anticipate interruption to the plant's overall operation.

Replacing MCCs 13 and 14 in the Dewatering Facility will also require short-term electrical shut down for the building. Ameresco plans to install a temporary generator during this electrical switchover to maintain dewatering operations at the facility.

4.5.8 Other

> Equipment Service Life

The equipment service life for the major components is as follows:

- Alfa Laval G2 Centrifuges: 15 years with routine maintenance per manufacturer's guidelines
- Schwing Bioset Cake Pumps: 15 years with routine maintenance per manufacturer's guidelines

> Compatibility with Existing Systems

This ECM will replace the major components of the dewatering system (i.e. centrifuges and cake pumps). Based on the preliminary design, we anticipate the new equipment can use the existing sludge feed and polymer systems. Because the new equipment will have lower power requirements, no issues with the existing electrical system are anticipated. The new equipment will come with PLC controls anticipated to interface with the plant's DCS.

4.6 ECM 7: Lighting System Upgrade

4.6.1 Overview

TMWRF last upgraded the lighting system at the plant in 2007. While most of the interior lighting system at the plant was upgraded at the time, much of the exterior lights were not. The most common lighting system inside the buildings is a 4 foot light fixture with 32 W T8 fluorescent lamps and electronic ballasts. The fixtures' configurations vary from building to building. Office spaces typically have ceiling-recessed troffer light fixtures. Buildings used to house process equipment typically have vapor-tight wrap fixtures with explosion-proof wraps in some places, such as the Digester Gas Compressor Room. Other interior spaces have ceiling- or pendant-mounted strip fixtures with industrial wire-cage guards.

Some interior spaces have 34 W T12 fluorescent lamps and magnetic ballasts in the light fixtures. The shops and warehouses have high bay fixtures with metal halide lamps for interior lighting. Several stairways inside the buildings have wallpack fixtures with HPS lamps for illumination. We also noted a few incandescent lamps for interior lighting in some locations.


Typical light fixtures at TMWRF: Administration Building (left); Nitrification Pump Station (right)

Exterior lighting for the building is typically a wallpack fixture with 50 W HPS lamps. Some exterior wallpack fixtures have screw-in compact fluorescent lamps instead of the HPS lamps. In addition to the exterior lighting for buildings, decks and stairways of the process tanks and basins also have exterior lighting. Tanks and basins are typically illuminated by pole-mounted shoebox light fixtures with HPS lamps; some pole-mounted fixtures have mercury vapor lamps instead.

Lighting controls for the offices and laboratories at TMWRF are typically wall-mounted toggle switches, although some spaces have occupancy sensors for controls. Interior spaces in the process-related buildings typically have wall-mounted occupancy sensors. Some of these sensors also have user-operated electronic timers in addition to the automated occupancy controls. The under- and above-ground galleries all have occupancy sensors. Exterior lights for the buildings and the process basins are controlled by electronic timers. A detailed list of all the existing lighting system at the plant is provided in Appendix H.

4.6.2 Recommendations

Ameresco recommends retrofitting existing light fixtures with newer and more efficient lighting technology. Installing lighting controls wherever applicable is also recommended. Retrofitting these existing fixtures and lamps with more efficient alternates and installing automated controls will reduce peak demand and electricity consumption at TMWRF.

Ameresco's lighting strategy is to standardize the proposed system as much as is practical. Every fixture throughout the project scope area containing standard efficiency 4 foot T8 or T12 lamps will be replaced or retrofitted with premium efficiency T8 lamps and high-quality electronic ballasts. Ballast output will be tailored to each specific location to obtain desired light levels without sacrificing energy savings. A premium lamp and ballast combination will be used for the majority of fluorescent retrofits, which yield maximum energy savings without sacrificing light output or quality. Standard 32 W and premium 25 W T8 technologies are interchangeable,[1] with no perceivable difference in quantity or quality of light. The 25 W, low-mercury T8 lamp has a color temperature of 4100 Kelvin (K) and will be used in all applications where 4 foot-long, straight lamps are installed. Fixtures that are old, broken, and otherwise in disrepair will be removed and replaced with new high-quality light fixtures. Please reference Appendix H for a room-by-room lighting audit, which provides the exact location of fixtures to be replaced.

HPS lamps will be replaced with Light Emitting Diode (LED) lamps, which use less electricity and provide better light quality. They also have very long life, which will reduce replacement frequency and lamp replacement costs. New fixtures will be installed for HPS wall-pack fixtures that are replaced.

Ameresco recommends installing occupancy sensors in private offices, conference rooms, and restrooms that do not already have them for lighting control. Time-based controls will be installed in open areas, hallways, and parts of mechanical rooms. Other areas will be further evaluated for the installation of sensors or controls. Lighting controls realize savings simply by turning lighting off when the rooms are unoccupied and lighting is not needed.

4.6.3 Scope of Work

The scope of work for this ECM includes installation or retrofit of 1,597 fixtures at all the buildings and exteriors included in Table 4.15. The ECM will include the installation of the lamps, ballasts, wiring, and kits needed for a complete project. The scope of work for the lighting controls retrofit includes controls installation at 105 locations included in Table 4.15.

[1] Both lamp technologies can operate using instant start ballasts. The 25-watt lamps will not operate properly if a rapid-start electronic ballast is installed.

Table 4.15. Lighting Scope of Work

Retrofit	Total (quantity)
Lighting Fixtures	
Linear Fluorescent Relamp and Reballast	864
Linear Fluorescent Relamp and Reballast, and Reflector	93
New Linear Fluorescent Fixtures	178
New Exit Sign LED	77
New Compact Fluorescent	9
New Exterior LED	376
Totals Retrofits	**1,597**
Lighting Controls	
Occupancy Sensor Ceiling Mount with Photocell Option	30
Occupancy Sensor Wall Mount with Photocell Option	59
Timer Control Wall Mount – 1 Circuit	14
Photo Sensor for On/Off	2
Totals Retrofits	**105**

The majority of the retrofits will involve replacing lamps, ballasts, and adding reflector kits as applicable at the fixtures. Some of the retrofits will involve replacing the existing fixtures. The following is a general overview of the retrofit. A detailed room-by-room list of all of the proposed retrofits is provided in Appendix H.

- Replace existing 32 W T8 lamps with premium 25 W T8 lamps and electronic ballasts. Add reflector kit retrofit to the existing fixtures if needed.
- Replace existing T8 lamps, electronic ballasts and install retrofit kits for all U-shaped fixtures in the buildings.
- Replace existing 34 W T12 lamps and magnetic ballasts with premium 25 W T8 lamps and electronic ballasts.
- Replace existing high-bay metal halide fixtures with high-bay fluorescent fixtures with premium T8 lamps and electronic ballasts.
- Replace existing incandescent lamps with compact fluorescent lamps.
- Replace existing incandescent and compact fluorescent exit signs in the buildings with LED exit signs with battery backup.
- Replace exterior wallpack HPS fixtures with new flood fixtures with LED lamps.
- Replace exterior pole-mounted HPS fixtures for the process basins with new shoebox fixtures and LED lamps.

The following is a general list of the lighting controls retrofit.

- Wall-mounted switch sensors will be installed to replace existing wall switches where the location of the existing wall switch does not block the operation of the occupancy sensor.
- Where the wall-mounted sensor switch is blocked, or in large areas and restrooms, a ceiling mounted occupancy sensor will be installed.
- In addition to the sensor, a power pack will be installed between the switch and the sensor.
- Time-based controls will be installed to replace key and switches that are centrally located to control lighting in open areas.

4.6.4 Baselines and Assumptions

The following assumptions were made in the development of this ECM:

- Savings for this ECM are calculated using estimates of the operating hours of the fixtures evaluated during the audit. These estimates are based on the typical operating hours at the plant, as well as on the actual lighting run hours as measured by the light loggers installed during the audit. An overall summary of the typical operating hours are listed in Table 4.16. A room-by-room list of all operating hours used in the calculation is provided in Appendix H.
- Light fixture wattage inputs are estimated based on observations during the audit, building drawings, and feedback from facility operators.
- Construction costs provided in this FGOA are estimated and assume that all work surfaces are free of asbestos and other hazardous materials. TMWRF is responsible for any hazardous material abatement during construction.
- The scope of work does not include any improvements to bring the existing electrical distribution system up to code.

Table 4.16. Estimated Annual Hours of Operation

Space Description	Annual Operation Hours (hours)
Corridors and Lobbies	3,432
Offices and Laboratories	3,276
Shops and Warehouses	3,016
Equipment Rooms	4,732
Connecting Galleries	5,694
Exterior Lighting	4,368

4.6.5 Detailed Energy Analysis

Table 4.17 provides a summary of savings for ECM 7.

Table 4.17. Summary of Cost Savings for ECM 7

Source	Savings ($)	Additional Costs ($)
Electricity Cost Savings	25,675	
O&M Savings	4,759	
Total Net Savings	**$30,434**	

> Energy Savings

Spreadsheet calculations were performed to determine the savings associated with ECM 7. Please reference Appendix H for these calculations.

Energy savings from the lighting retrofit are determined by comparing the baseline existing kW and kWh used with the post-retrofit kW and kWh consumption. Total cost savings from the lighting retrofit is then calculated from the energy savings and the baseline energy cost for the buildings.

kW Savings = base kW – post kW

kWh Savings = base kWh – post kWh

kW $ Savings = kW savings x Demand Cost

kWh $ Savings = kWh savings x Energy Cost

Existing energy usage for lighting is calculated from the number of existing light fixtures at the buildings and their rated wattages, assuming a 95 percent lighting diversity factor.

Base kW = base quantity x base wattage x 95% diversity factor

Base kWh = base operating hours x base kW

Similarly, the energy usage post-retrofit is calculated using the new lower wattage of the lamps and ballasts combination. The calculation still assumes a 95 percent diversity factor post-retrofit; post-operating hours are assumed to be the same as the base operating hours.

Post kW = post quantity x post wattage x 95% diversity factor

Post kWh = post operating hours x post kW

The facility demand savings is the demand savings (kW) that will occur in the month with the highest demand of the year multiplied by 12 months.

Energy savings from the lighting controls installation is calculated by comparing the run hours of the light fixtures with and without the automated controls. To avoid double counting, previously used post-retrofit electricity consumption is used as the baseline in the calculation. The calculation for lighting controls energy savings is as follows:

kWh Savings = Base kWh – post kWh

Base kW = Post kW from lighting retrofit

Base kWh = Post kWh from lighting retrofit

Post kWh = Post operating hours x base kW

kWh $ Savings = kWh savings X Energy Cost

There are no peak demand savings for controls installation since the savings are intermittent.

> Maintenance Savings

The proposed replacement lamps and ballasts have a longer service life than the existing lamps and ballasts. This, in turn, will reduce TMWRF's maintenance costs from reduced lamps and ballasts replacement. However, only material cost savings are included for this ECM.

The material cost savings is calculated based on the operating hours and expected service life of the lamps and ballasts before and after retrofit. Detailed spreadsheet calculation for this savings is included in Appendix H.

> Savings Interactions

Retrofitting the lighting system at the buildings will reduce the cooling load in the summer months by lowering the heat gains to the space from the light fixtures. Conversely, it will increase heating use during winter months due to the loss of that same heat gain. The following calculations provide a summary of the resultant calculations. An 8 month heating period and 4 month cooling period in the Reno, Nevada area has been assumed. Cooling and heating system efficiencies are assumed to be 10 SEER and 80 percent, respectively. The ventilation rate used is 10 percent.

Cooling kWh Savings = Light Heat Savings / 12,000 ton-hr/Btu / Cooling Eff

Light Heat Savings = Light kWh Savings x (1 – % Vent) x % Cooling per year x 3412 Btu/kWh

Heat penalty = Light Heat Lost / Heating Eff

Light Heat lost = Light kWh Savings x % Vent x % Heating per year x 3412 Btu/kWh

For this project, Ameresco does not include the monetary heating penalty in the cash flow because TMWRF currently does not pay for the digester gas used to generate building heating. Cooling savings from lighting retrofit is included only for the buildings that have mechanical cooling. Many buildings in the plant have an evaporative cooler or no mechanical cooling at all.

4.6.6 References

Data obtained from TMWRF:

- Architectural, mechanical and electrical drawings
- Electric bills

General data:

- Field notes
- Lighting manufacturer catalogs
- Kaufman, John E. and Christensen, Jack F. *IES Ready Reference*. Illuminating Engineering Society of North America. 1989.
- U.S. Department of Energy. *Advanced Lighting Guidelines*. Report Number DOE/EE-0008. 1993.
- Illuminating Engineering Society of North America. *IES Lighting Handbook*. 1999.

4.6.7 Utility Interruptions

Lighting installation will be performed during the unoccupied times of the spaces during the construction period. Typically, this is done after normal hours so that the installation does not interfere with facility occupants. In those spaces that have 24 hour operations, the project manager will coordinate specific times for the installation with the building management and staff that minimizes any potential impacts or interrupts to normal business operations. Our goal is to install the retrofits so that building occupants are unaware of Ameresco's presence.

4.6.8 Other

> Equipment Service Life

The equipment service life for the major components is as follows:

- Lighting fixtures: 20 years
- Lighting controls: 20 years
- Electronic fluorescent ballasts: 100,000 run hours
- Two and four foot fluorescent lamps: 42,000 hours
- LED Lamps: 100,000 run hours

> Compatibility with Existing Systems

The lighting retrofit will not have compatibility issues with existing systems.

4.7 ECM 9: Near-Term Dewatering Improvement

4.7.1 Overview

Prior to this project, TMWRF had contracted CH2MHILL to identify several near-term improvements needed at the Solids Dewatering Facility. A major part of the improvements is the upgrade to the existing polymer system at the facility. However, the recommendations also include critical items to be addressed immediately, such as upgrades to the electrical and ventilation systems. Centrifuges and cake discharge pumps replacement are not part of this ECM's scope. Rather, they are included in ECM 6 (Section 4.5).

4.7.2 Recommendations

Ameresco recommends that TMWRF include the near-term dewatering improvement project into the overall ESCO project. As part of the ESCO project, Ameresco recommends replacing the centrifuges and cake discharge pumps at the facility to reduce the biosolids disposal costs (Section 4.5). Because there is overlap between Ameresco's proposal for the facility and the near-term improvement project, it is beneficial to combine the two projects together. TMWRF will benefit from having one point of accountability for the upgrades in the facility, and eliminates the potential for miscommunication between separate contractors. Furthermore, the overall construction cost will be lower by eliminating duplicate mobilization cost, overhead cost, etc. The construction period will be shorter due to a more streamlined coordination of the field work.

4.7.3 Scope of Work

The scope of this ECM includes all the work identified in CH2MHILL's design and drawing marked "For Review Only" dated April 2013. The construction cost guarantee for this ECM is also based on this drawing and the specifications provided by CH2MHILL. The drawings and specifications documents used as references are included in Appendix J.

The following is a summary list of the scope of work for this ECM:

- Complete cleaning and partial coating removal for the inside of four existing dewatered sludge hoppers. Submit condition assessment and repair work plan if required. Perform repair. Final blast and recoat.
- Demolition of existing polymer system and centrate lines inside Solids Dewatering Facility
- Installation of new neat polymer transfer system in the Solids Dewatering Facility
- Demolition of existing ferric chloride storage and feed system inside Chemical Building No. 3

- Installation of new polymer in Chemical Building No. 3
- Modifications to existing alum and centrate piping in Pipe Gallery
- Installation of new dewatered sludge piping and demolition of existing sludge piping inside Solids Dewatering Facility
- Installation of new HVAC systems for Solids Dewatering Facility
- Installation of new handrails on the roof of Solids Dewatering Facility
- Construction of a new MCC room and drain trough inside Solids Dewatering Facility
- Expansion of existing air purge system
- Foul air ductwork
- Installation of new covered grating in hopper room
- Replacement of centrate drain and sampling lines. Installation of new sampling system
- Electrical, instrumentation, and control work
- Design and installation of required equipment and pipe support systems

4.7.4 Baselines and Assumptions

The following assumptions were made in the development of this ECM:

- Ameresco developed the construction cost based on the drawings and specifications provided by CH2MHILL (April 2013). We assumed that the final "For Construction" drawings and specifications are the same or with negligible changes from the ones provided to us.
- Ameresco assumes that CH2MHILL will participate in the project construction as the engineering consultant.
- Ameresco assumes that programming of the plant's DCS will be performed by TMWRF staff, Mr. Mark Bowman. Ameresco will be responsible for the controls and programming for the PLCs and other field controllers. In the last major upgrade to the plant in 2005, Mr. Bowman performed the changes to the DCS.

4.7.5 Detailed Energy Analysis

> Energy Savings

This ECM is a capital improvement project to address near-term needs in the Solids Dewatering Facility. Ameresco does not claim any energy or utility savings from this ECM.

> Maintenance Savings

Ameresco does not claim maintenance savings from this ECM.

> Savings Interactions

There is no savings interaction between this ECM and the other ECMs.

4.7.6 References

Data obtained from TMWRF:

- Architectural, mechanical and electrical drawings
- Electricity, polymer, and biosolids hauling bills
- CH2MHILL drawings "Solids Dewatering Facility – Near-Term Improvement Project" dated April 2013

General data:

- Field notes and photos

4.7.7 Utility Interruptions

Demolition of existing ferric chloride system and installation of the new neat polymer system at Chemical Building No. 3 will require shutdown of that building. TMWRF informed Ameresco that the existing ferric chloride system in the building is no longer in use. Therefore, demolition and installation work can commence without interrupting the plant's operation.

Work inside the Solids Dewatering Facility will require a shutdown for approximately two months. Ameresco will install a temporary dewatering system outside of the facility during the shutdown period to handle the sludge produced from plant process. With the temporary dewatering system in place, Ameresco does not anticipate any interruption to the plant's overall operation.

4.7.8 Other

> Equipment Service Life

The equipment service life for the major components is as follows:

- Polymer system: 15 years
- HVAC system: 15 years
- Electrical system: 20 years

> Compatibility with Existing Systems

The new polymer system will use the existing polymer type currently in use by TMWRF. No compatibility issues are anticipated. The new HVAC system will improve ventilation and odor control inside the facility; otherwise, the new systems will have no impact on the dewatering process. All control upgrades will be compatible with TMWRF's existing DCS.

4.8 ECM 10: MyEnergyPro™

4.8.1 Overview

TMWRF utilizes several different tools to track energy and utility usage at the plant. The DCS provides staff and operators with electrical demand and consumption data for some of the major process equipment. TMWRF also has six digester gas meters connected to the DCS for monthly reporting of gas production. There are also other various process monitoring and controls sensors that track the chemical use for other processes.

These existing utility monitoring tools are not integrated; instead, they serve to provide supplementary information to the main process monitoring system. It is often difficult and time-consuming to collect and combine all of the separate data together to form a complete picture of the plant's energy and utility use. Much of the data is not readily compatible, as some are measured on a daily basis while others are collected as monthly averages.

4.8.2 Recommendations

Ameresco recommends implementing the MyEnergyPro™ (MEP) software suite for TMWRF to better monitor the energy and utility use at the plant. MEP is a suite of web-based energy information products developed by Ameresco to provide clients with an integrated tool to monitor utility consumption. Using MEP, TMWRF can view real-time energy consumption and renewable generation on its own unique MEP site. Historical utility and savings data can be viewed in charts and graphs and exported to Microsoft® Excel for further analysis. Using the built-in variance report, TMWRF can identify potential billing errors. The software also includes alarm and forecast modules with easily customizable settings and algorithms.

Ameresco recommends installing a display kiosk at TMWRF to provide staff and visitors with an interactive tool to educate users about the plant's operation and commitment to environmental sustainability. Ameresco has developed an industry-leading kiosk and web display system designed to engage all facets of TMWRF and the Washoe County community in activities pertaining to resource conservation. The program includes physical display kiosks, as well as an interactive web layer designed to pinpoint wasteful behaviors, educate individuals on the importance of reducing waste, measure program results, and provide feedback through interactive displays. Overall, the system is structured to foster a community-wide attitude that values efficiency and sustainability.

Integrated with real-time utility data, the system monitors utility consumption within targeted areas or zones. The systems are fully customizable to the needs and objectives of TMWRF. TMWRF could include animated educational videos, interactive workshops to explore energy usage, and explanations of energy technologies, including solar PV and cogeneration. In addition, the system can function as a general communication tool for the TMWRF, ensuring that vital information is readily accessible to staff and community members. The displays can be designed to include TMWRF announcements, news, closures, community involvement opportunities, and any other TMWRF communications needs.

4.8.3 Scope of Work

As part of the project, Ameresco will provide MyEnergyPro UtilityPRO, where TMWRF can view its monthly bills and savings, including electric, chemicals, waste disposal, in one comprehensive chart. The monthly usage will be compared with the facility's baseline usage, which can have weather normalization, facility changes, and set point adjustments. Key utility data can be displayed in a table report format, and exported to Microsoft® Excel or an image file. With proper permissions, a client can also view its measurements and verification report, which shows the monthly savings as well as the guaranteed amount. The savings is displayed in both usage and dollars, and converted to pounds of CO_2 for greenhouse gas impact. The variance report compares monthly usage, rate, and demand from year to year, and color-coded based on the difference. This report provides users with ability to easily identify potential errors in their facilities' utility bills.

A second component of the MyEnergyPro system for TMWRF will be DashPRO, where near-to-real time digester gas electricity generation can be viewed in charts and graphs. The renewable data will also be integrated with the existing Reno Green Energy Dashboard at greenenergy.reno.gov, and displayed on a website as well as a kiosk for public dissemination.

> UtilityPRO

The following monthly data will be tracked on UtilityPRO:

- Total three electricity meters from NV Energy
- Two chemical bills (aluminum sulfate and methanol)
- Sludge hauling bills Western NV Transport
- Sludge disposal bills from Waste Management
- Invoices for 3rd party fertilizer purchase from the plant. These invoices will be provided by Ostara Nutrient Recovery Technology as part of the Crystal Green fertilizer product off-take agreement from ECM 2 (reference Section 4.2).

The following activities are included as part of initial implementation:

- Configure MyEnergyPro with site and meter information, including meter number, site square footage, location, etc.
- Import historical billing data
- Download historical weather data
- Calculate weather normalization coefficients for each site
- Review data with customer
- Onsite training

The following functions are included on the MEP website upon implementation:

- Monthly utility billing report for the utilities listed previously on one centralized portal. Other utility can be added over time.
- Monthly utility charts and graphs
- Automated bill import from utility companies, if applicable
- Weather normalization
- Variance report with a year-to-year comparison function
- M&V analysis and reporting
- ENERGY STAR integration, if applicable
- Export data function to csv or Microsoft® Excel file

Hardware and software licenses included:

- Servers: MEP for will reside on the Ameresco network. Ameresco will provide server space for both the web and SQL servers

> DashPRO

The ESCO project will include a renewable energy systems which will be included in the DashPRO sites:

- Biogas cogeneration system (850 kW)

DashPRO will also track six digester gas meters at the plant:

- Digester gas flow meter for sludge heaters 1 and 2
- Digester gas flow meter for sludge heaters 3 and 4
- Digester gas flow meter for sludge heater 5
- Digester gas flow meter for the flare

- Digester gas flow meter for the compressed digester gas
- Digester gas flow meter for the dewatering building boiler

The following scopes of work are included as part of initial project implementation:

- Install a data gateway and electric meter to acquire data for the biogas cogeneration system
- Develop front end using MEP DashPRO
- Install kiosk to display renewable production data

On-going maintenance will include the following:

- Monitor data alarms
- Repair data, if required
- Coordinate data acquisition related troubleshooting

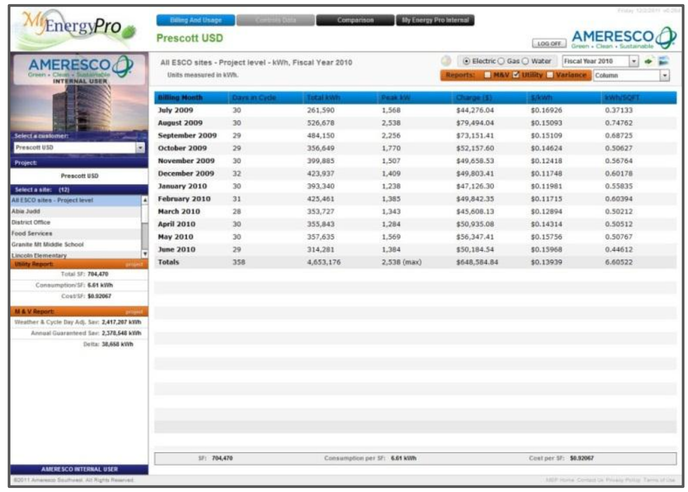
> Maintenance and Support

The following continuing maintenance and support services are included in the ECM scope:

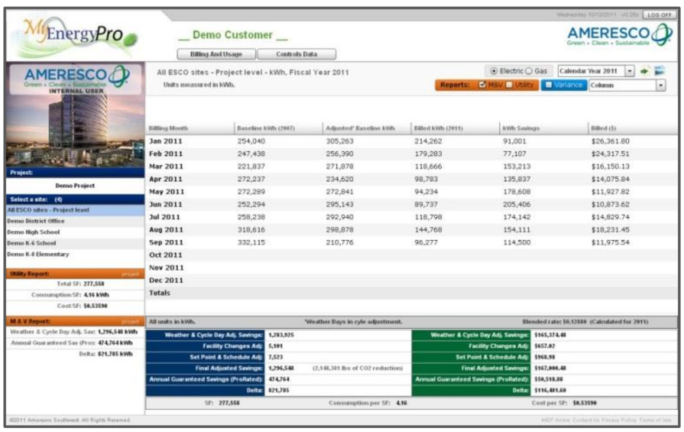
- Server maintenance: Both the web and SQL servers will reside at the Ameresco data center. Routine system updates will be performed as part of the IT server maintenance. Ameresco will ensure the general health of the servers, as well as the network that the servers are hosted on.
- Monthly utility data import: Ameresco will be responsible for the manual download of utility data where applicable, and the successful completion of automated data import jobs.
- Controls data nightly archive: Ameresco will ensure the successful completion of nightly data archive of data, such as room setpoints.
- Software upgrades: Software upgrades are included in annual maintenance procedures.
- Software defects repair: Ameresco will be responsible for fixing software defects discovered in the web application.
- Help desk: Ameresco's MEP team will provide email and phone assistance for MEP website-related issues during regular business hours.

The follow pages include sample screenshots for MEP UtilityPRO and DashPRO modules, as well as the City of Reno, Nevada and Lake Havasu City's existing MEP systems.

Sample screenshot – MEP UtilityPRO column chart

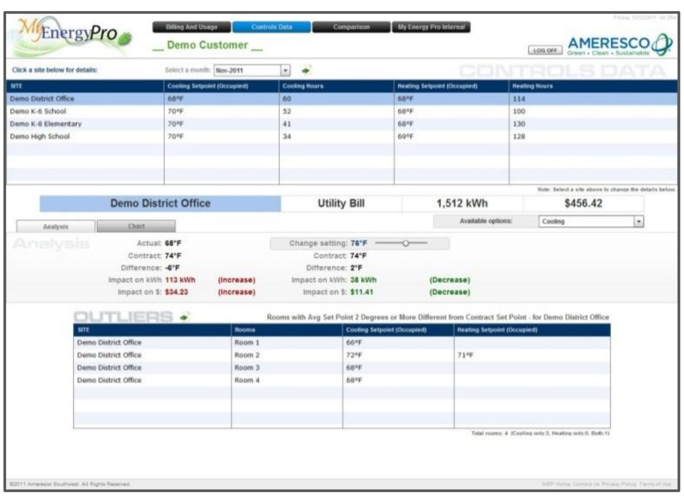


Sample screenshot – MEP UtilityPRO utility report



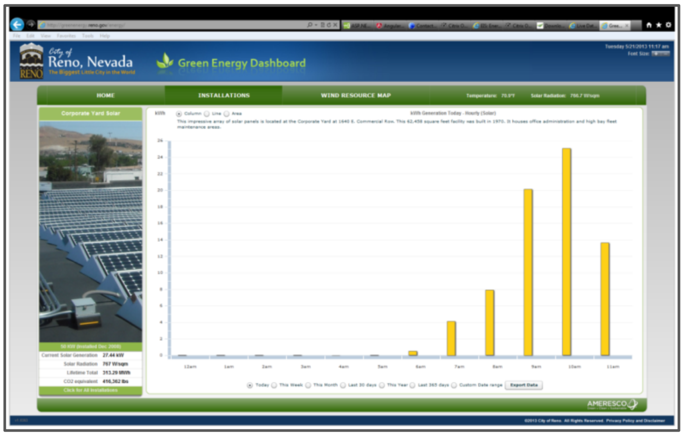
Sample screenshot – MEP UtilityPRO M&V report.

Sample screenshot – MEP UtilityPRO variance report.



Sample screenshot – MEP UtilityPRO controls module.

Sample screenshot – MEP DashPRO City of Reno homepage



Sample screenshot – MEP DashPRO City of Reno chart.

Sample screenshot – MEP DashPRO Lake Havasu City

4.8.4 Baselines and Assumptions

The following assumptions were made in the development of this ECM:

- A local network through TMWRF is assumed to be available for the biogas cogen system. Additional cellular modem cost may be incurred if it is not.
- It is assumed that Ameresco will use the existing digester gas meters. Data from the meters are assumed to be available to MEP (e.g., through FTP upload).

4.8.5 Detailed Energy Analysis

> Energy Savings

Ameresco does not claim any energy or utility savings from this ECM.

> Maintenance Savings

Ameresco does not claim maintenance savings from this ECM.

> Savings Interactions

There is no savings interaction between this and other ECMs.

4.8.6 References

Data obtained from the TMWRF:

- Architectural, mechanical and electrical drawings
- Electricity, chemicals, and biosolids disposal bills
- Digester gas meters locations and readings
- DCS and TIMS reports

General data:

- Field notes and photos

4.8.7 Utility Interruptions

Installation of the MyEnergyPro software will be done independently of the plant's process operation. No utility interruption is anticipated during installation.

4.8.8 Other

> Equipment Service Life

The equipment service life for the major components is as follows:

- MEP Software: Technical maintenance and support provided for the 15 years performance period

> Compatibility with Existing Systems

MyEnergyPro™ is an independent, web-based software product for energy and utility monitoring. It will be used primarily as a monitoring tool and will not interfere with the treatment process in any way. Interface between MEP and data collection equipment will be made through remote connection. Utility data from bills and invoices that are not available electronically will be manually entered into the system.

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5.0 Project Costing

Ameresco offers open book pricing for the project. We will provide a breakdown of the material Ameresco purchases, turnkey contractor costs, labor costs, and other miscellaneous costs for each measure.

The total costs consist of our material purchases for the cogeneration engine, centrifuges, lamps, ballasts, and other materials and equipment. The labor costs represent the installation of the equipment and all other turnkey installation of the measures. The total costs also include engineering, project management, commissioning, training, warranty, and others.

Ameresco's approach to performance contracting has a number of benefits for TMWRF:

- Despite engineering at approximately 10 percent complete, the prices provided are guaranteed maximum values. We do not issue change orders unless the client wishes to add additional scope.
- Any cost reductions identified during value engineering will transfer to contingency.
- Contingency is used first for contractor costs not identified during initial project development, then for client-directed modifications.
- Direct costs include contingency amounts which vary from 5 to 10 percent depending on the level of certainty of field conditions, progress toward final engineering, and construction risk.
- Unused contingency is refunded to the client via a deductive change order following completion of the project.
- Pricing includes operational functionality guarantee at project completion and a one-year material and workmanship warranty.
- Prices provided are open book. Documentation for all direct costs will be provided. Direct costs include Ameresco purchased equipment and subcontractor labor, equipment, and material costs.
- Ameresco has proactively provided a 1.4 percent fee discount versus those identified in our Statement of Qualifications to assist TMWRF obtain project funding.
- All conservation measures besides lighting were priced using the lower fee renewable energy project pricing structure.

Cost breakdowns of the project are provided in Table 5.1. The subsequent tables show the cost breakdown for each ECM. A preliminary construction schedule for the project is also provided in this section.

Table 5.1. Cost Breakdown for the Project

Item	All Other ECMs ($)	Markup (%)	ECM 7 Only	Markup (%)
Direct Costs Subject to Markup	18,286,551		281,487	
Design Oversight	822,895	4.50%	19,704	7%
Construction Management	640,029	3.50%	21,112	7.5%
Project Administration	182,866	1%	5,630	2%
Contract Administration	137,149	0.75%	4,222	1.5%
Project Warranty	45,716	0.25%	1,407	0.5%
Training	45,716	0.25%	5,630	2%
Commissioning	182,866	1%	8,445	3%
Initial M&V at Construction	91,433	0.50%	4,222	1.5%
Travel	91,433	0.50%	8,445	3%
Discount	-$256,012	-1.40%		0%
Subtotal of Costs (*subject to markup*)	**$20,270,642**		**$360,303**	
Overhead	**$2,027,064**	**10.0%**	**$36,030**	**10.0%**
Profit	**$1,824,358**	**9.0%**	**$32,427**	**9.0%**
Implementation Cost	**$24,550,824**			
Financial-Grade Operational Audit Fee	$149,835			
Performance and Payment Bond	$210,930			
Total Project Costs	**$24,911,589**			
Third Party Consultant Fee	$125,000			
Total Costs	**$25,036,589**			

Table 5.2. Cost Breakdown for ECM 2: Centrate Nutrient Recovery

Item	ECM 2 ($)	Markup (%)
Direct Costs Subject to Markup	5,125,300	
Design Oversight	230,639	4.50%
Construction Management	179,386	3.50%
Project Administration	51,253	1%
Contract Administration	38,440	0.75%
Project Warranty	12,813	0.25%
Training	12,813	0.25%
Commissioning	51,253	1%
Initial M&V at Construction	25,627	0.50%
Travel	25,627	0.50%
Discount	-$71,754	-1.40%
Subtotal of Costs (*subject to markup*)	**$5,681,395**	
Overhead	**$568,140**	**10.0%**
Profit	**$511,326**	**9.0%**
Implementation Cost	**$6,760,860**	

Table 5.3. Cost Breakdown for ECM 4A: Biogas Cogeneration

Item	ECM 4A ($)	Markup (%)
Direct Costs Subject to Markup	3,879,091	
Design Oversight	174,559	4.50%
Construction Management	135,768	3.50%
Project Administration	38,791	1%
Contract Administration	29,093	0.75%
Project Warranty	9,698	0.25%
Training	9,698	0.25%
Commissioning	38,791	1%
Initial M&V at Construction	19,395	0.50%
Travel	19,395	0.50%
Discount	-$54,307	-1.40%
Subtotal of Costs (*subject to markup*)	**$4,299,972**	
Overhead	**$429,997**	**10.0%**
Profit	**$386,998**	**9.0%**
Implementation Cost	**$5,116,967**	

Table 5.4. Cost Breakdown for ECM 4B: Digester Domes Rehabilitation

Item	ECM 4B ($)	Markup (%)
Direct Costs Subject to Markup	2,366,583	
Design Oversight	106,496	4.50%
Construction Management	82,830	3.50%
Project Administration	23,666	1%
Contract Administration	17,749	0.75%
Project Warranty	5,916	0.25%
Training	5,916	0.25%
Commissioning	23,666	1%
Initial M&V at Construction	11,833	0.50%
Travel	11,833	0.50%
Discount	-$33,132	-1.40%
Subtotal of Costs (*subject to markup*)	**$2,623,357**	
Overhead	**$262,336**	**10.0%**
Profit	**$236,102**	**9.0%**
Implementation Cost	**$3,121,795**	

Table 5.5. Cost Breakdown for ECM 6: Dewatering System Upgrade

Item	ECM 6 ($)	Markup (%)
Direct Costs Subject to Markup	4,599,003	
Design Oversight	206,955	4.50%
Construction Management	160,965	3.50%
Project Administration	45,990	1%
Contract Administration	34,493	0.75%
Project Warranty	11,498	0.25%
Training	11,498	0.25%
Commissioning	45,990	1%
Initial M&V at Construction	22,995	0.50%
Travel	22,995	0.50%
Discount	-$64,386	-1.40%
Subtotal of Costs (*subject to markup*)	**$5,097,995**	
Overhead	**$509,799**	**10.0%**
Profit	**$458,820**	**9.0%**
Implementation Cost	**$6,066,614**	

Table 5.6. Cost Breakdown for ECM 7: Lighting System Upgrade

Item	ECM 7 ($)	Markup (%)
Direct Costs Subject to Markup	281,487	
Design Oversight	19,704	7.0%
Construction Management	21,112	7.5%
Project Administration	5,630	2.0%
Contract Administration	4,222	1.5%
Project Warranty	1,407	0.5%
Training	5,630	2.0%
Commissioning	8,445	3.0%
Initial M&V at Construction	4,222	1.5%
Travel	8,445	3.0%
Discount		0%
Subtotal of Costs (*subject to markup*)	**$360,303**	
Overhead	**$36,030**	**10.0%**
Profit	**$32,427**	**9.0%**
Implementation Cost	**$428,761**	

Table 5.7. Cost Breakdown for ECM 9: Near Term Dewatering Improvement

Item	ECM 9 ($)	Markup (%)
Direct Costs Subject to Markup	2,278,196	
Design Oversight	102,519	4.50%
Construction Management	79,737	3.50%
Project Administration	22,782	1%
Contract Administration	17,086	0.75%
Project Warranty	5,695	0.25%
Training	5,695	0.25%
Commissioning	22,782	1%
Initial M&V at Construction	11,391	0.50%
Travel	11,391	0.50%
Discount	-$31,895	-1.40%
Subtotal of Costs (*subject to markup*)	**$2,525,380**	
Overhead	**$252,538**	**10.0%**
Profit	**$227,284**	**9.0%**
Implementation Cost	**$3,005,202**	

Table 5.8. Cost Breakdown for ECM 10: MyEnergyPro™

Item	ECM 10 ($)	Markup (%)
Direct Costs Subject to Markup	38,378	
Design Oversight	1,727	4.50%
Construction Management	1,343	3.50%
Project Administration	384	1%
Contract Administration	288	0.75%
Project Warranty	96	0.25%
Training	96	0.25%
Commissioning	384	1%
Initial M&V at Construction	192	0.50%
Travel	192	0.50%
Discount	-$537	-1.40%
Subtotal of Costs (*subject to markup*)	**$42,542**	
Overhead	**$4,254**	**10.0%**
Profit	**$3,829**	**9.0%**
Implementation Cost	**$50,625**	

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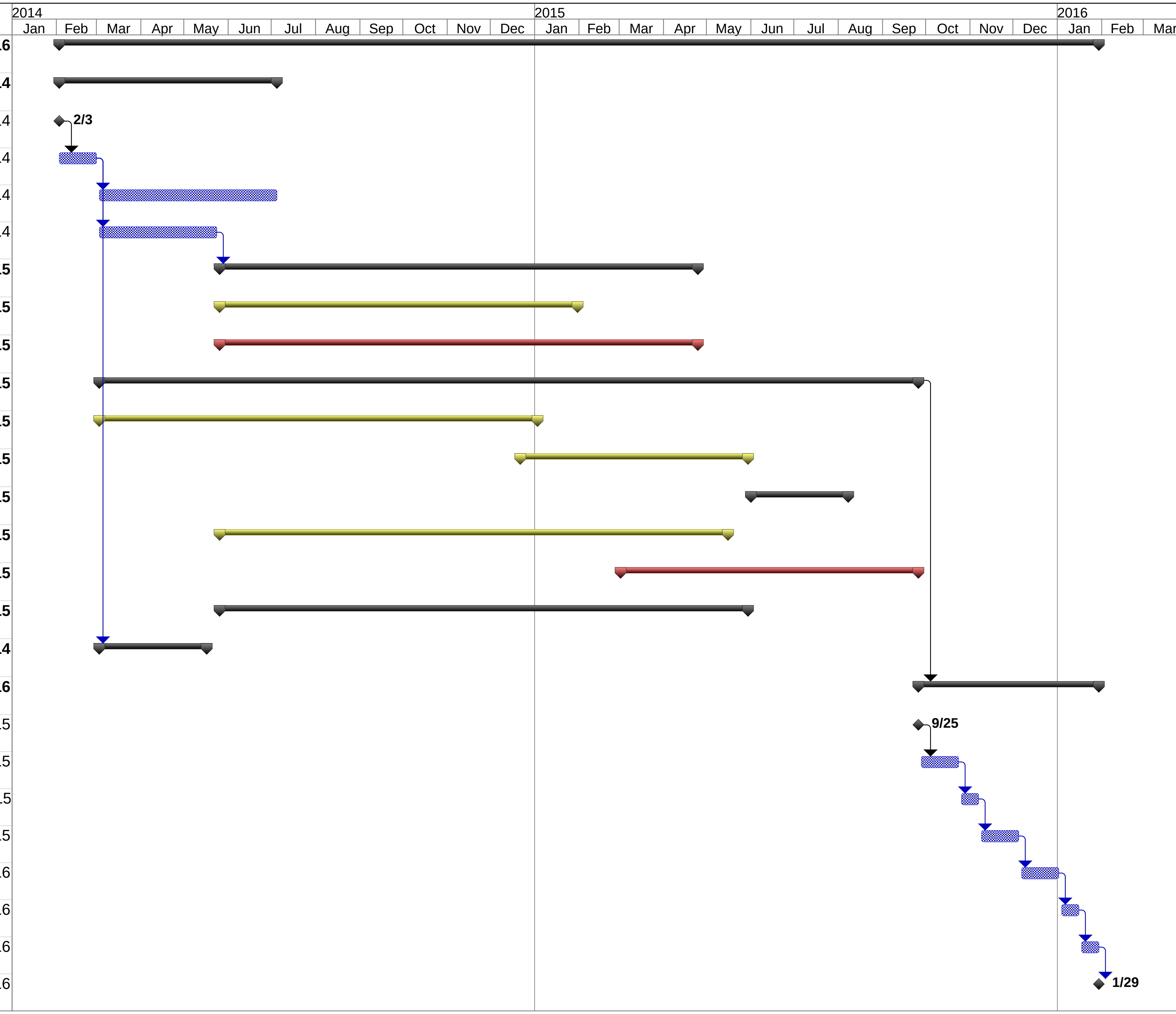
TRUCKEE MEADOWS WRF
PRELIMINARY CONSTRUCTION SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Truckee Meadows WRF**	**520 days**	**Mon 2/3/14**	**Fri 1/29/16**
2	**Pre-construction**	**110 days**	**Mon 2/3/14**	**Fri 7/4/14**
3	Project kick-off and notice to proceed	0 days	Mon 2/3/14	Mon 2/3/14
4	Subcontracts	20 days	Mon 2/3/14	Fri 2/28/14
5	Process ECMs engineering design	90 days	Mon 3/3/14	Fri 7/4/14
6	Early procurement documents	60 days	Mon 3/3/14	Fri 5/23/14
7	**Long Lead Procurement**	**240 days**	**Mon 5/26/14**	**Fri 4/24/15**
8	**ECM 4A: Biogas Cogeneration**	**180 days**	**Mon 5/26/14**	**Fri 1/30/15**
13	**ECM 6: Dewatering System Upgrade**	**240 days**	**Mon 5/26/14**	**Fri 4/24/15**
18	**Process ECMs Construction**	**410 days**	**Mon 3/3/14**	**Fri 9/25/15**
19	**ECM 2: Centrate Nutrient Recovery**	**220 days**	**Mon 3/3/14**	**Fri 1/2/15**
28	**ECM 4A: Biogas Cogeneration**	**115 days**	**Mon 12/22/14**	**Fri 5/29/15**
35	**ECM 10: MyEnergy Pro**	**50 days**	**Mon 6/1/15**	**Fri 8/7/15**
41	**ECM 4B: Digester Domes Rehabilitation**	**255 days**	**Mon 5/26/14**	**Fri 5/15/15**
51	**ECM 6: Dewatering System Upgrade**	**150 days**	**Mon 3/2/15**	**Fri 9/25/15**
61	**ECM 9: Near Term Dewatering Improvement**	**265 days**	**Mon 5/26/14**	**Fri 5/29/15**
76	**ECM 7: Lighting System Upgrade**	**55 days**	**Mon 3/3/14**	**Fri 5/16/14**
81	**Project Closeout and Completion**	**90 days**	**Fri 9/25/15**	**Fri 1/29/16**
82	Project substantial completion	0 days	Fri 9/25/15	Fri 9/25/15
83	Punchlist completion	20 days	Mon 9/28/15	Fri 10/23/15
84	Documentation	10 days	Mon 10/26/15	Fri 11/6/15
85	Commissioning	20 days	Mon 11/9/15	Fri 12/4/15
86	Post-construction M&V	20 days	Mon 12/7/15	Fri 1/1/16
87	Final Inspection and Acceptance	10 days	Mon 1/4/16	Fri 1/15/16
88	Training	10 days	Mon 1/18/16	Fri 1/29/16
89	Performance Period Begins	0 days	Fri 1/29/16	Fri 1/29/16



Project: Truckee Meadows WRF
Date: 12/10/2013

Task	Project Summary	Inactive Task	Duration-only	Finish-only
Split	External Tasks	Inactive Milestone	Manual Summary Rollup	Progress
Milestone	External Milestone	Inactive Summary	Manual Summary	Deadline
Summary	Inactive Task	Manual Task	Start-only	

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6.0 Measurement and Verification

The long-term success of any comprehensive energy efficiency program depends on the development of an accurate, successful measurement and verification (M&V) plan. The main objective is to develop a cost effective plan that quantifies and verifies the performance results of the ECMs. Ameresco subscribes to using industry standard M&V protocols that have been developed in response to the need for reliable and consistent measurement practices.

The following reference is used for the development of M&V procedures for this project:

- Efficiency Valuation Organization. International Performance Measurement & Verification Protocol (IPMVP). September 2010.
- The protocols also help to allocate various risks associated with achieving energy cost savings and allowing risk reduction and better risk management. The M&V options description, provided herein, was developed by summarizing the IPMVP and contains excerpts taken from that document. The benefits of the protocols are as follows:
  - Defining the role of verification in energy contracts and implementation.
  - Discussing procedures, with varying levels of accuracy and cost, for verifying:
    - Baseline and project installation conditions, and
    - Long-term energy savings performance.
  - Providing techniques for calculating "whole-facility" savings, individual technology savings, and stipulated savings.
  - Providing procedures that are consistent, industry accepted, impartial, and reliable.
  - Providing procedures for the investigation and resolution of disagreements related to performance issues.

The general approach to determining energy savings in these plans involves comparing the energy use of the retrofitted system before installation of the ECM (baseline) and after installation of the ECM (post-retrofit). In general:

Energy Savings = Baseline Energy Use – Post Retrofit Energy Use

The IPMVP protocols have defined four M&V options (Options A through D) that meet the needs of a wide range of performance contracts and provide suggested procedures for baseline development and post-retrofit verification. These M&V options are flexible and reflect the considerations previously mentioned. The options are summarized in Table 6.1.

Table 6.1. Measurement and Verification Options

M&V Option	How Savings Are Calculated	Typical Applications
Option A: Partially Measured Retrofit Isolation		
Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous of the error they may introduce. Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are stipulated.
Option B: Retrofit Isolation		
Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
Option C: Whole Facility (Calibrated Building Modeling)		
Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month base year period and throughout the post-retrofit period.
Option D: Calibrated Simulation (Bill Comparison)		
Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end- use metering.	Multifaceted energy management program affecting many systems in a building but where no base year data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

Table 6.2 below lists the proposed M&V plans for the ECMs. Of the 7 ECMs developed for the project, only 4 ECMs are projected to produce savings that need to be measured and verified. ECMs 4B, 9, and 10 are capital projects that do not require M&V after construction.

Table 6.2. M&V Plan Summary

ECM	IPMVP Option
ECM 2: Centrate Nutrient Recovery	
Crystal Green Fertilizer Savings	C
Alum Savings	B
Alum Biosolids Hauling and Disposal Savings	A
Methanol Savings	A
ECM 4a: Biogas Cogeneration System	
Electricity Generation	B
ECM 4b: Digester Domes Rehabilitation	
(No Savings to Verify)	n/a
ECM 6: Dewatering System Upgrade	
Biosolids Hauling Frequency Reduction	C
Biosolids Disposal Weight Reduction	C
ECM 7: Lighting System Upgrade	
Lighting Retrofit Savings	A
Lighting Controls Savings	A
ECM 9: Near-Term Dewatering Improvement	
(No Savings to Verify)	n/a
ECM 10: MyEnergyPro™	
(No Savings to Verify)	n/a

More comprehensive M&V plan summaries for the ECMs are shown in Table 6.3 to Table 6.6.
The sections that follow provide a detailed description of how the savings
will be verified. M&V plan details are provided only for those ECMs that produce savings. Results of the M&V services will be reported to TMWRF on an annual basis.

Table 6.3. Summary of M&V Plan for ECM 2: Centrate Nutrient Recovery

Savings Source	IPMVP Option	Baseline M&V Requirements	Post Retrofit M&V Requirements	Measurement and Metering	Stipulated Variables	Performance Period M&V Requirements
Crystal Green fertilizer	C	None. This is a new process.	Amount of Crystal Green® fertilizer produced in tons.	Ameresco will analyze the fertilizer purchase invoices from Ostara annually to verify this savings.	Baseline centrate properties and Orthophosphate load is stipulated from TMWRF's historical data. Baseline Crystal Green® fertilizer production will be adjusted if centrate properties and Orthophosphate load is significantly different than historical data.	Annual inspection of the Pearl® nutrient recovery system. Annual review of the centrate properties and Orthophosphate load going to the Pearl® nutrient recovery system.
Alum Savings	B	Baseline alum consumption for existing Phosphorous Removal System (PRS).	Alum consumption for PRS after ECM implementation.	Alum consumption for the PRS will be measured using existing flow meter.	Alum dry tonnage in the liquid solution will be calculated using chemical properties data provided by manufacturer. Baseline alum consumption will be adjusted if centrate properties and Orthophosphate load is significantly different than historical data.	Annual inspection of the Pearl® nutrient recovery system. Annual review of the centrate properties and Orthophosphate load going to the Pearl® nutrient recovery system.
Alum Biosolids Hauling and Disposal Savings	A	None.	Amount of Crystal Green® fertilizer (tons) produced.	Reduction in biosolids from deferred Alum use is related to the amount of Phosphor removed from the centrate. Ameresco will use the verified amount of fertilizer produced to calculate the amount of P removed.	Theoretical weight ratio of P in fertilizer, biosolids weight ratio per pound of P, and centrifuge efficiency will be stipulated. Reduction in biosolids hauling frequency will be calculated using average tonnage data per truck pick up.	Annual inspection of the Pearl® nutrient recovery system. Annual review of the centrate properties and Orthophosphate load going to the Pearl® nutrient recovery system.

Table 6.3. Summary of M&V Plan for ECM 2: Centrate Nutrient Recovery

Savings Source	IPMVP Option	Baseline M&V Requirements	Post Retrofit M&V Requirements	Measurement and Metering	Stipulated Variables	Performance Period M&V Requirements
					Reduction in biosolids disposal tonnage will be calculated based on the amount of P removed and the stipulated parameters.	
Methanol Savings	A	None.	Amount of Crystal Green® fertilizer (tons) produced.	Reduction in methanol use correlates to the ammonia load reduction in the centrate. Ameresco will calculate the reduction in ammonia load based on the amount of fertilizer produced.	Theoretical weight of N in fertilizer will be stipulated. Reduction in methanol cost will be calculated based on % ammonia load reduction in the centrate, and using the unit methanol price.	Annual inspection of the Pearl® nutrient recovery system. Annual review of the centrate properties and Ammonia load going to the Pearl® nutrient recovery system.

Table 6.4. Summary of M&V Plan for ECM 4A: Biogas Cogeneration System

Savings source	IPMVP Option	Baseline M&V Requirements	Post Retrofit M&V Requirements	Measurement and Metering	Stipulated Variables	Performance Period M&V Requirements
Electricity Generation	B	None.	Actual kWh produced by the cogeneration system.	Ameresco will meter the net electricity generated by the cogeneration system.	Digester gas flow rate is stipulated from TMWRF's historical meter data. Baseline kWh production will be adjusted if actual digester gas flow rate is significantly lower than historical data.	Annual inspection of the cogeneration system. Annual review of the digester gas production data.

Table 6.5. Summary of M&V Plan for ECM 6: Dewatering System Upgrade

Savings Source	IPMVP Option	Baseline M&V Requirements	Post Retrofit M&V Requirements	Measurement and Metering	Stipulated Variables	Performance Period M&V Requirements
Biosolids Hauling Frequency Reduction	C	Baseline biosolids hauling frequency (number of pick-ups) before ECM implementation from invoices.	Biosolids hauling frequency (number of pick-ups) after ECM implementation from invoices.	Ameresco will analyze the biosolids hauling invoices annually to verify this savings.	Biosolids production is stipulated from TMWRF's historical data. Baseline biosolids hauling frequency will be adjusted if actual biosolids production is significantly different than historical data.	Annual inspection of the centrifuges, cake conveyance system, and polymer system. Annual review of the biosolids production data.
Biosolids Disposal Weight Reduction	C	Baseline biosolids disposal tonnage before ECM implementation from invoices.	Biosolids disposal tonnage after ECM implementation from invoices.	Ameresco will analyze the biosolids disposal invoices and tonnage annually to verify this savings.	Biosolids production is stipulated from TMWRF's historical data. Baseline biosolids disposal tonnage will be adjusted if actual biosolids production is significantly different than historical data.	Annual inspection of the centrifuges, cake conveyance system, and polymer system. Annual review of the biosolids production data.

Table 6.6. Summary of M&V Plan for ECM 7: Lighting System Upgrade

Savings Source	IPMVP Option	Baseline M&V Requirements	Post Retrofit M&V Requirements	Measurement and Metering	Stipulated Variables	Performance Period M&V Requirements
Lighting Retrofit Savings	A	Input power of select existing light fixtures. Run hours of select existing light fixtures.	Input power of select new light fixtures.	Short-term metering of power consumption for select light fixtures. Short-term metering of run hours for select light fixtures. Number of selected fixtures must be statistically significant.	Power consumption of light fixtures that are not metered. Operating hours of light fixtures.	Annual inspection of a percentage of retrofitted light fixtures.
Lighting Controls Savings	A	Operating hours of select light fixtures before controls retrofit.	Operating hours of select light fixtures after controls retrofit.	Short-term metering of run hours for select light fixtures before and after controls retrofit. Number of selected fixtures must be statistically significant.	Light fixtures power consumption will be stipulated from lighting retrofit metering. Reduction of operating hours of light fixtures.	Annual inspection of a percentage of retrofitted lighting controls.

6.1 Utility Rate Summary

Energy savings will be calculated using the applicable unit of energy (kWh, tons of fertilizer, tons of biosolids, etc.) The following table summarizes the value of each of the different types of utility savings that will be used to calculate dollar savings in each year of the Measurement and Verification period.

Table 6.7. Utility Rate Summary

	Electricity ($/kWh)	Methanol ($/gal)	Alum ($/ton)	Fertilizer ($/ton)	Biosolids Hauling Fee ($/ pick up)	Biosolids Disposal Fee ($/ton)
Construction	$ 0.06017	$ 1.782	$ 385	$ 250	$ 99.90	$ 11.68
Year 1	$ 0.06191	$ 1.833	$ 396	$ 250	$ 103.09	$ 11.96
Year 2	$ 0.06370	$ 1.886	$ 408	$ 250	$ 106.38	$ 12.24
Year 3	$ 0.06554	$ 1.941	$ 419	$ 250	$ 109.77	$ 12.53
Year 4	$ 0.06743	$ 1.997	$ 431	$ 250	$ 113.27	$ 12.83
Year 5	$ 0.06938	$ 2.055	$ 444	$ 250	$ 116.88	$ 13.14
Year 6	$ 0.07139	$ 2.114	$ 457	$ 250	$ 120.61	$ 13.45
Year 7	$ 0.07345	$ 2.175	$ 470	$ 250	$ 124.46	$ 13.77
Year 8	$ 0.07557	$ 2.238	$ 484	$ 250	$ 128.43	$ 14.10
Year 9	$ 0.07776	$ 2.303	$ 498	$ 250	$ 132.53	$ 14.43
Year 10	$ 0.08000	$ 2.369	$ 512	$ 250	$ 136.75	$ 14.78
Year 11	$ 0.08232	$ 2.438	$ 527	$ 250	$ 141.12	$ 15.13
Year 12	$ 0.08469	$ 2.508	$ 542	$ 250	$ 145.62	$ 15.49
Year 13	$ 0.08714	$ 2.581	$ 558	$ 250	$ 150.26	$ 15.86
Year 14	$ 0.08966	$ 2.655	$ 574	$ 250	$ 155.06	$ 16.24
Year 15	$ 0.09225	$ 2.732	$ 590	$ 250	$ 160.00	$ 16.62

6.2 ECM 2: Centrate Nutrient Recovery

6.2.1 Crystal Green Fertilizer Savings

The M&V protocol for this savings source is based on IPMVP Option C. For this savings, Ameresco will verify the amount of Crystal Green fertilizer produced by the Pearl process from the monthly fertilizer purchase invoices.

After the Pearl process installation, Ostara will come to the plant every 2-3 weeks to collect the fertilizer produced. The collected fertilizer will then be analyzed, sorted, and weighed for resale through Ostara's distribution network. Ostara in turn will reimburse TMWRF for the amount of fertilizer that is deemed acceptable for resale. Ameresco will use this amount from the monthly invoice to verify that the savings are realized.

Measured Variables:

- Crystal Green fertilizer amount (in tons)

Stipulated Variables:

- Unit price of Crystal Green fertilizer = $250 per ton

> Cost Savings Calculations

Total annual savings for TMWRF from this source will be calculated as follows:

Annual fertilizer revenue = Measured fertilizer tonnage x $250/ton

6.2.2 Alum Savings

The M&V protocol for this savings source is based on IPMVP Option B. For this savings, Ameresco will measure the amount of Aluminum Sulfate (Alum) solution that TMWRF uses before and after the Pearl process installation. The measurement will be performed using existing flow meter and SCADA system. Baseline consumption of the chemical will be the last 12 months of metered data before installation. Post-retrofit consumption will be trended continuously through the SCADA.

Although the chemical is delivered as liquid solution, the vendor charges TMWRF based on the dry tonnage of the chemical. To determine the cost savings, we will calculate the amount of dry Alum in the solution using manufacturer's chemical properties data.

Measured Variables:

- Baseline Alum Sulfate consumption (in gallons per day)
- Post-retrofit Alum Sulfate consumption (in gallons per day)

Stipulated Variables:

- Alum solution density = 11.8 lbs/gal
- Dry Alum content in solution = 48.8%
- Unit price of dry Alum = $385 per ton

> Cost Savings Calculations

Total annual Alum Sulfate solution savings will be calculated as follows:

Baseline annual Alum solution = (Σ Baseline daily Alum consumption)$_{for\ year}$

Post-retro annual Alum solution = (Σ Post-retro daily Alum consumption)$_{for\ year}$

Annual Alum solution savings = Baseline annual Alum solution – Post-retro annual Alum solution

The amount of dry Alum saved will be calculated based on the annual Alum solution savings.

Annual dry Alum savings = Annual Alum solution savings x Solution density x % dry Alum ratio

Annual dry Alum savings (lbs/yr) = Annual Alum solution savings (gal/yr) x 11.8 lbs/gal x 48.8%

The weight of dry Alum in tonnage is then:

Annual dry Alum savings (ton/yr) = Annual dry Alum savings (lbs/yr) / 2,000 lbs/ton

Cost savings to TMWRF from not using this chemical is then:

Alum cost savings = Annual dry Alum savings (ton/yr) x $385/ton

6.2.3 Alum Biosolids Hauling and Disposal Savings

The M&V protocol for this savings source is based on IPMVP Option A. The amount of biosolids reduction at TMWRF from reduction in Alum chemical use will be calculated based on the measured production of Crystal Green fertilizer in the previous M&V. Cost savings at the landfill will then be calculated based on this biosolids reduction. Cost savings from reduced biosolids pick-up frequency will be calculated based on the baseline amount of biosolids hauled per pick up.

Measured Variables:

- Crystal Green fertilizer amount (in tons)

Stipulated Variables:

- Fertilizer acceptance rate = 90%
- P weight ratio in fertilizer = 12.7%
- Biosolids dry weight ratio per P = 4.87 lb/lb
- Centrifuge wet/dry biosolids ratio = 6.41 wet lb/dry lb
- Baseline hauling load = 23 tons/pick up
- Hauling cost = $99.90 per pick up
- Landfill cost = $11.68 per ton

> Cost Savings Calculations

Annual fertilizer tonnage is obtained from the previous M&V work. The fertilizer amount in the invoice is the amount acceptable for resale. Assuming a 90% acceptance rate, the actual fertilizer produced at the reactor is then:

Annual fertilizer produced = Measured fertilizer tonnage / 90%

The Crystal Green fertilizer is an equimolar crystalline matrix of magnesium, ammonium, and phosphate: $NH_4MgPO_4.6(H_2O)$. The molar ratio of P in the fertilizer is 12.7% by weight. Therefore, the annual amount of P removed from the centrate is:

Annual P removed = Annual fertilizer produced x 12.7%

After the Pearl process installation, TMWRF will no longer use Alum to remove P from the centrate. This deferred chemical use is the reason for the reduction in biosolids production. Theoretically, every pound of P precipitated using Alum will generate 4.87 pounds of dry biosolids. The amount of biosolids saved from not using Alum can then be calculated as follows:

Annual dry biosolids savings = Annual P removed x 4.87 lb/lb

The biosolids that is ultimately hauled off the plant and disposed of at the landfill is not completely dry because the centrifuges cannot completely separate the biosolids from the water. Existing centrifuges at the plant generate on average 6.41 lbs of wet solid per one pound of dry solid. As such, the amount of wet biosolids that need to be hauled off the plant is then:

Annual wet biosolids savings = Annual dry biosolids savings x 6.41 lb/lb

This reduction in wet biosolids will save TMWRF money in two ways: (1) by reducing the number of pick-ups needed by the trucking company to haul the biosolids to the landfill, and (2) by reducing the amount of biosolids disposed at the landfill. On average, the trucking company picks up 23 tons of wet biosolids each time they come to the plant. Using this average load, the savings in number of hauling pick-ups is:

Hauling pick up saved = Annual wet biosolids savings / 23 tons/pick up

Hauling cost savings = Hauling pick up saved x $99.90/pick up

The landfill operator charges TMWRF a disposal cost based on the amount of wet biosolids. The baseline unit cost for disposal is $11.68 per wet ton. The reduction in wet biosolids will then reduce TMWRF's disposal cost by:

Disposal cost savings = Annual wet biosolids savings x $11.68 per ton

6.2.4 Methanol Savings

The M&V protocol for this savings source is based on IPMVP Option A. Installing the Pearl process will reduce methanol consumption at the plant because the process also partially removes nitrogen from the centrate. The amount of N reduction after installation will be determined based on the amount of fertilizer produced. The methanol cost savings from this reduction will then be calculated using baseline parameters.

Measured Variables:

- Crystal Green fertilizer amount (in tons)

Stipulated Variables:

- Fertilizer acceptance rate = 90%
- N weight ratio in fertilizer = 5.72%
- Baseline plant total N load = 7,120 lbs/day
- Baseline plant methanol use = 2,984 gal/day
- Methanol cost = $1.78 per gallon

> Cost Savings Calculations

Annual fertilizer tonnage is obtained from the previous M&V work. The fertilizer amount in the invoice is the amount acceptable for resale. Assuming a 90% acceptance rate, the actual fertilizer produced at the reactor is then:

Annual fertilizer produced = Measured fertilizer tonnage / 90%

The Crystal Green fertilizer is an equimolar crystalline matrix of magnesium, ammonium, and phosphate: $NH_4MgPO_4.6(H_2O)$. The molar ratio of N in the fertilizer is 5.72% by weight. Therefore, the annual amount of N removed from the centrate is:

Annual N removed = Annual fertilizer produced x 5.72%

Daily N removed = Annual N removed / 365 days

Baseline daily total N load at the plant, including both centrate load and main process load, is 7,120 lbs/day. So, the daily percent N load savings is:

% daily N removed = Daily N removed / 7,120 lbs/day

Baseline methanol use at the plant is 2,984 gal/day, and the consumption is linear with the N load in the water. The amount of methanol saved from N load reduction is then:

Daily methanol savings = % daily N removed x 2,984 gal/day

Annual methanol savings = Daily methanol savings x 365 days

Cost savings to TMWRF from reduced methanol use can then be calculated using the baseline unit price of methanol.

Methanol cost savings = Annual methanol savings x $1.78 per gal

6.3 ECM 4A: Biogas Cogeneration System

6.3.1 Electricity Generation

The M&V protocol for this savings source is based on IPMVP Option B. For this ECM, savings will be verified by continuously metering the electricity produced by the cogeneration system. Metered data from the system will be monitored via the MyEnergyPro™ suite to be installed in ECM 10.

Measured Variables:

- Electricity production from the system as metered

Stipulated Variables:

- None

> Cost Savings Calculations

Ameresco's guarantee applies to the electricity production of the cogeneration system.

Annual electricity savings = Actual metered production data

Cost savings from this ECM will then be calculated using the Time-of-Use rate schedule, as appropriate.

6.4 ECM 6: Dewatering System Upgrade

6.4.1 Biosolids Hauling Frequency Reduction

The M&V protocol for this savings source is based on IPMVP Option C. Reduction in biosolids hauling cost will be verified by comparing the invoiced pick-up frequency before and after the upgrades. Monthly invoices from the hauling company will contain the number of pick-ups per month, as well as the tonnage of the biosolids hauled.

Baseline hauling frequency before upgrade will be the last 12 months invoiced before the upgrades are completed. Hauling frequency after upgrades will be compiled and analyzed annually.

Measured Variables:

- Hauling frequency before upgrade from invoice
- Hauling frequency after upgrade from invoice

Stipulated Variables:

- Baseline biosolids tonnage = 23 tons/pick up
- TMWRF will be responsible to ensure the hauling company fills the truck to full, per pick up
- Hauling cost = $99.90 per pick up

> Cost Savings Calculations

Total reduction in hauling frequency will be the difference in frequency before and after the upgrades.

Total hauling frequency savings = Baseline hauling frequency – Post upgrade hauling frequency

As described previously, ECM 2 will also reduce biosolids hauling frequency. To isolate the hauling frequency savings due to ECM 6 upgrades only, the total hauling frequency savings from the invoices must be adjusted.

Adjusted hauling frequency savings = Total hauling frequency savings – ECM 2 hauling savings

Annual hauling cost savings for this ECM is then:

Hauling cost savings = Adjusted hauling frequency savings x $99.90/pick up

6.4.2 Biosolids Disposal Weight Reduction

The M&V protocol for this savings source is based on IPMVP Option C. Reduction in biosolids disposal cost will be verified by comparing the invoiced tonnage of biosolids at the landfill before and after the upgrades. Each time the hauling company brings the biosolids to the landfill, it is weighed before disposed of. Monthly invoices from the landfill company will contain this weighed tonnage.

Baseline biosolids tonnage before upgrade will be the last 12 months invoiced before the upgrades are completed. Biosolids tonnage after upgrades will be compiled and analyzed annually.

Measured Variables:

- Biosolids disposed tonnage before upgrade from invoice
- Biosolids disposed tonnage after upgrade from invoice

Stipulated Variables:

- Landfill cost = $11.68 per ton

> Cost Savings Calculations

Total reduction in disposed biosolids tonnage will be the difference before and after the upgrades.

Total tonnage savings = Baseline biosolids tonnage – Post upgrade biosolids tonnage

As with hauling cost savings, ECM 2 will also reduce the amount of disposed biosolids. To isolate the savings due to ECM 6 only, the total tonnage savings must be adjusted.

Adjusted tonnage savings = Total tonnage savings – ECM 2 tonnage savings

Annual biosolids disposal cost savings for this ECM is then:

Disposal cost savings = Adjusted tonnage savings x $11.68/ton

6.5 ECM 7: Lighting System Upgrade

6.5.1 Lighting Retrofit Savings

The M&V protocol for this savings source is based on IPMVP Option A. Electricity reduction from the lighting retrofit will be verified by measuring a select number of light fixture's power before and after retrofit. The measurements will be done one time. Run hours for the light fixtures will be stipulated based on the logged run hours data collected during the energy audit.

Selection of light fixtures for measurement will be based on Federal Energy Management Program (FEMP) guide for sample sizing. For this ECM, we will use the number of samples that correspond to 80% confidence level with 20% precision.

Measured Variables:

- Baseline power consumption of selected light fixtures
- Post retrofit power consumption of selected light fixtures

Stipulated Variables:

- Run hours of light fixtures based on logged data collected in the audit. Table 6.8 shows the stipulated run hours.

Table 6.8. Baseline Run Hours by Room Types

Room Type	Annual Run Hours
Corridors and Lobbies	3,432
Offices and Laboratories	3,276
Shops and Warehouses	3,016
Equipment Rooms	4,732
Connecting Galleries	5,694
Exterior Lighting	4,368

> Cost Savings Calculations

Peak demand reduction from lighting retrofit will be determined based on the measured power consumptions.

Peak monthly kW savings = Baseline kW – Post retrofit kW

Peak annual kW savings = Peak monthly kW savings x 12 months

In our savings projection, we assumed that peak demand savings exist in only five buildings listed below. This is because the other buildings are process equipment buildings that are typically empty during peak periods. The only exception is the Reuse Irrigation Pump Station that has all emergency lights that are on 24/7.

- Administration Building
- Laboratory Building
- Maintenance/Warehouse Building
- Training Building
- Reuse Irrigation Pump Station

Electricity savings from lighting retrofit will be calculated from the measured power reduction and stipulated run hours.

$$\text{Annual kWh savings} = \Sigma\,[\,(\text{Baseline kW} - \text{Post retrofit kW}) \times \text{Run hours}\,]_{\text{for all fixtures}}$$

Cost savings from lighting retrofit will then be calculated using the Time-of-Use rate schedule, as appropriate.

6.5.2 Lighting Controls Savings

The M&V protocol for this savings source is based on IPMVP Option A. There is no peak demand savings for this savings source. Electricity savings will be realized from reduced run hours due to lighting controls. Post retrofit power consumption of the light fixtures after lighting retrofit will be used as the baseline power use for this savings verification. Similarly, run hours collected from the audit will be used as the baseline. The additional measurement scope for this savings source will be to install light loggers for at least two weeks to determine the new, reduced, run hours after controls installation.

As in the lighting retrofit M&V, a selection of lighting controls for measurement will be based on Federal Energy Management Program (FEMP) guide for sample sizing. We will use the number of samples that correspond to 80% confidence level with 20% precision.

Measured Variables:

- Power consumption of selected lighting fixtures
- Run hours of selected lighting fixtures after controls installation

Stipulated Variables:

- Baseline run hours of light fixtures based on logged data collected in the audit as shown in Table 6.8.

> Cost Savings Calculations

Electricity savings from lighting controls retrofit will be calculated from the measured light fixture power and run hours.

$$\text{Annual kWh savings} = \Sigma\,[\text{Post retro kW x (Baseline run hours – Post retro run hours)}]_{\text{for all fixtures}}$$

Cost savings from this lighting controls retrofit will then be calculated using the Time-of-Use rate schedule, as appropriate. Since the savings will occur mostly during off-peak period, the cost savings calculation must use the off-peak rates.

7.0 Commissioning Plan

The performance testing and commissioning matrix is provided in Table 7.1. This matrix is a summary of the commissioning plan for the recommended ECMs. Details of the plan will be developed during construction. Pre-functional and functional reports will be modified during the design and construction phases based on actual system design and installation. Results of pre-functional and functional testing will be included in the O&M manuals.

The commissioning process consists of two main steps: pre-functional check and functional testing. Pre-functional check is the verification process before, during, and after construction to ensure the system is installed according to design. This process includes verification of installed equipment according to engineering specifications and submittals, verification of installation work according to manufacturer's specifications, inspections for equipment or installation flaws or inconsistency, and other related inspection works. Pre-functional checks must be performed before a full functional testing can be performed. Each subcontractor will be responsible for their own individual checks prior to installing the equipment. Ameresco will be responsible for the project-wide pre-functional checks during and after construction to ensure the system installed is as designed.

The second step in the commissioning process, functional test, is the process of testing the installed systems to ensure that they operate as designed, and that they can achieve the performance as intended. In functional testing, operation of each equipment and their operation as a system is verified, such as motor speed, water flow and pressure, etc. Functional testing also includes testing the system performance under various simulated conditions (e.g. to simulate peak heating load if the test is conducted in the summer). Results of the tests will be recorded, and any discrepancies with design values will be noted. Necessary modifications will be performed to rectify the performance that does not conform to design. Generally, Ameresco will be responsible for conducting and supervising the functional test along with approved representatives from vendors and subcontractors. TMWRF's maintenance personnel are also encouraged to be involved in the process, as it will help in transitioning the operation and maintenance responsibilities.

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Table 7.1. Performance Testing and Commissioning Matrix

ECM Description	Systems to be Commissioned	Pre-functional Testing	Pre-functional Testing Responsibility	Functional Performance Testing (FPT)	Functional Testing Responsibility	Testing Documentation
ECM 2: Centrate Nutrient Recovery	New building, Pearl reactor, ancillary equipment, process controls.	Structural and mechanical inspection of the new building. Structural and mechanical inspection of the Pearl reactor and other ancillary equipment. Mechanical and electrical inspection of the pipes, joints, electrical MCC, electrical connections, etc. Test all motors for proper rotation. Perform point-by-point check of the process controls.	Structural, mechanical, electrical, and controls contractors.	Functional testing of the Pearl system will be done in accordance with Ostara's start-up and commissioning guidelines. Functional testing for process controls and interface with TMWRF's DCS will be done with TMWRF.	Contractors, Ameresco, Ostara, and TMWRF.	Completed start up and commissioning checklists and spreadsheets for the Pearl system will be provided to TMWRF.
ECM 4A: Biogas Cogeneration System	Jenbacher engine, electrical interconnection, heat recovery system.	Visual inspection of all installed system. Check mechanical connections for the digester gas, hot water, heat exchangers, etc. Check electrical connections to and from the engine, at the transformer, and at the main switchgear.	Mechanical and electrical contractors. Engine manufacturer.	Functional testing of the system will be done in accordance with the engine manufacturer's start-up and commissioning guidelines. Functional testing for engine controls and interface with TMWRF's DCS will be done with Carollo and TMWRF.	Contractors, engine manufacturer, Ameresco, Carollo, and TMWRF.	Completed start up and commissioning checklists and spreadsheets for the engine and the supporting systems will be provided to TMWRF.
ECM 4B: Digester Domes Rehabilitation	New digester domes.	Structural inspection of the new domes. Check for cracks, creep, and other structural anomalies. Mechanical inspection of the digester gas collection system on top of the domes.	Structural and mechanical contractors.	Perform tests at sample locations near the domes to check for gas leaks.	Ameresco.	Gas leak test procedures and results will be documented and provided to TMWRF.

Table 7.1. Performance Testing and Commissioning Matrix

ECM Description	Systems to be Commissioned	Pre-functional Testing	Pre-functional Testing Responsibility	Functional Performance Testing (FPT)	Functional Testing Responsibility	Testing Documentation
ECM 6: Dewatering System Upgrade	New centrifuges and cake pumps, process controls system.	Visual inspection of centrifuges and cake pumps installation, both mechanical and electrical. Verify installation of the new biosolids conveyance pipes and their lubrication rings. Perform point-by-point check of the process controls.	Mechanical and electrical contractors.	Functional testing for the centrifuges and cake pumps will be done in accordance with the manufacturer's start-up and commissioning guidelines. Functional testing for dewatering system controls and interface with TMWRF's DCS will be done with Carollo and TMWRF.	Contractors, equipment manufacturers, Ameresco, Carollo, and TMWRF.	Completed start up and commissioning checklists and spreadsheets for the system will be provided to TMWRF.
ECM 7: Lighting System Upgrade	Lighting fixtures and lighting controls.	Visually verify operation of fixtures as completed. Visually verify operation of sensors as completed.	Electrical contractor.	Measure light levels and power input for select number of fixtures per FEMP 80/20 method. For select number of light controls, verify that sensing devices are calibrated to perform as designed.	Electrical contractor and Ameresco.	Lighting Commissioning Data Sheets will be completed for all new fixtures. Lighting controls functional test results will be provided in spreadsheet format listing areas served, sensor location, sensor type, and fixtures controlled.
ECM 9: Near-Term Dewatering Improvement	New polymer system, new HVAC.	Visual inspection of the new polymer system at Chemical building #3. Check mechanical and electrical installations of the tanks, pumps, and other supporting equipment. Visual inspection of the new HVAC system at the Dewatering building.	Mechanical and electrical contractors.	Verify that the polymer aging system achieves the design condition. Verify that the polymer delivery system works correctly. Verify operations of the new exhaust fans at the Dewatering building.	Contractors, Ameresco, Carollo.	Commissioning report for the system will be provided after tests are completed.

Table 7.1. Performance Testing and Commissioning Matrix

ECM Description	Systems to be Commissioned	Pre-functional Testing	Pre-functional Testing Responsibility	Functional Performance Testing (FPT)	Functional Testing Responsibility	Testing Documentation
				More detail commissioning plan for this ECM will be developed during construction.		
ECM 10: MyEnergyPro™	Touch-screen kiosk and web portal.	Visual inspection of the touch screen kiosk installation. Verify that the kiosk is connected to the internet.	Ameresco.	Verify that the program correctly reads the data from the meters. Verify TMWRF's login access to the web portal and that the information provided is correct.	Ameresco.	Ameresco will generate the first month report from MyEnergyPro™ as part of the commissioning.

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7.1 Acceptance Procedures and Documentation

Upon completion of the pre-functional testing and prior to completion of the functional performance testing, Ameresco will submit Certificates of Substantial Completion for ECMs that are providing a performance and financial benefit to TMWRF. The Certificates of Substantial Completion will have accompanying punch lists; all punch list items that could directly affect the potential to generate energy cost savings must be completed prior to functional performance testing. Note that the warranty periods for equipment/systems that are in operation will begin upon execution of the Certificates of Substantial Completion.

Upon completion of all punch list items that could potentially affect an ECM to generate energy cost savings, the functional performance tests will be completed. Upon successful completion of these tests, the ECMs are deemed to have the potential to achieve the estimated energy cost and maintenance savings. Ameresco will then formally request from TMWRF an inspection of the work completed. A Certificate of Acceptance of Construction Completion and Inspection will accompany the formal inspection request. The Certificate of Acceptance of Construction Completion and Inspection formally acknowledges that the work has been completed, or a portion thereof, and is being accepted. Some ECMs may not be able to be completed at that time due to circumstances beyond Ameresco's control. In these instances, a percentage complete will be assigned to the ECM, and a punch list of outstanding items will be included. Typically, these items will not have an impact on the savings or the potential to achieve savings because the functional performance test will have been completed prior to requesting the final inspection. All outstanding punch list items will be completed as soon as possible.

O&M manuals will be provided upon completion of all functional performance tests and upon completion of the as-built documentation. All necessary training will be provided as outlined herein.

Documentation to be provided include O&M manuals, which will be contained in a sturdy binder with 8.5-inch by 11-inch sheets and consist of the following sections and information:

Section I – System Description

- A detailed description of each system, including its major components and function.
- Control strategies and sequences describing start-up, modes of operation, and shutdown.
- Procedures for the operation of every system including all required emergency instructions and safety precautions.
- Reduced scale schematic or piping and instrument diagram drawings depicting system overviews.

Section II – Equipment Data Sheets

- Corrected shop drawings, including performance curves, efficiency ratings, features and options.
- Copies of approved certifications and factory test reports (where applicable).
- Wiring and control schematics detailing the operation and control of each component for troubleshooting.
- Manufacturer's O&M manuals.
- Manufacturer's spare parts list.
- Manufacturer recommended spare parts inventory list.
- Manufacturer's recommended lubricating schedule including type, grade, temperature and frequency.
- Name, address and telephone number of the manufacturer's local representative for each type of equipment for replacement parts and service.

Section III – Maintenance

This section will be modified for each project based on the maintenance requirements of the contract.

Section IV – Test Reports

- Pre-functional reports (equipment start-up reports and commissioning data sheets).
- Functional reports (system start-up reports and functional performance tests).
- Copies of welder certifications (where applicable).
- Non-destructive testing reports (where applicable).
- Hydrostatic/pneumatic pipe testing reports (where applicable).
- Water treatment analysis and report (where applicable).
- Testing and balancing reports (where applicable).
- Other reports as applicable.

Section V – Warranties/Guarantees

- A type written warranty, on company letterhead, for each system installed. The warranty will state the system and components covered, the duration of the warranty period, and emergency contact phone numbers for service and repair.
- Warranties/guarantees from subcontractors or equipment suppliers.

7.2 Training Plan

Training and orientation on the systems installed will vary depending on the complexity of the specific equipment installed for each ECM. Training will be provided in the following levels:

1. For systems and/or equipment that are essentially direct replacements of existing equipment, and where no additional specific skills will be required to perform operations and maintenance functions, training will be limited to a general overview of the equipment installed and a review of the O&M manuals. Training will be directed to TMWRF facilities operations and maintenance personnel. The review of the O&M manuals will provide staff with familiarity with the equipment that is installed, manufacturer's recommended maintenance procedures, and warranty information. Training should be provided at the completion of construction of each of the ECMs.
2. For systems/equipment that are new to the site and require some general understanding as to their function and operation, training will include a minimal amount of classroom time that will provide an overview of the technology and any specific maintenance or operations requirements. Following the classroom training, a site tour will be conducted to view the installation and operation of the equipment. Training should occur at both the onset and completion of construction. Equipment cut sheets will be provided at the beginning of construction and will provide a general description of the equipment, function, and operation. At the conclusion of construction, the O&M manuals will provide parts lists and warranty information.
3. For systems and/or equipment that are new to the site and more complex in nature, training will be directed to both the facilities engineering and the O&M personnel. In general, training will consist of classroom training followed by hands-on instruction in the field. Training will be provided through a complement of Ameresco personnel, design engineers, installation contractors, and manufacturer's representatives, as necessary, and will be dictated by the complexity of the installation, participant's prior experience with the equipment that is installed, and contractual obligations. Specifics on the training program, including schedule and training materials, will be further refined during the design process, but the training, in general, will consist of the following:
    - Explanation of the design concept
        - Design intent
        - Energy efficiency considerations
        - Seasonal modes of operation
        - Emergency conditions and operation
        - Comfort conditions and indoor air quality

- Systems operation
  - Operation of individual components, instruction from authorized factory technicians, if required
  - Physical location of critical shut-off valves, fire, smoke and balancing dampers, relief valves, safeties, and control panels
  - System operational procedures for all modes in manual and automatic modes
- Operation of the control systems
  - Sequences of operation
  - Use of graphical user interfaces
  - Alarms and problem indicators
  - Diagnostics and corrective actions
- Service and maintenance
  - Use of the O&M manuals
  - Instruction and logging procedures for lubrication
  - Instruction from authorized factory technicians, where applicable
  - Troubleshooting and investigation of malfunctions
  - Recommended procedures for collecting, interpreting and storing specific performance data

Table 7.2 lists the training plans for the ECMs in this project. Typically, no formal training activities are scheduled prior to project acceptance. Training prior to acceptance will be through hands-on experience during construction, M&V, and commissioning. For this reason, Ameresco strongly encourages TMWRF staff to be actively involved in the design and construction phase of the project. After project acceptance, Ameresco will arrange for formal training workshops for TMWRF staff. These training events will be recorded on DVD for future training purposes. All training activities will be coordinated with TMWRF.

Table 7.2. Training Plan

ECMs	Training Level	Classroom Training (hrs)	Field Training (hrs)
ECM 2: Centrate Nutrient Recovery	Level 3	2 x 4 hrs	2 x 4 hrs
ECM 4A: Biogas Cogeneration System	Level 3	2	2
ECM 4B: Digester Domes Rehabilitation	n/a	n/a	n/a
ECM 6: Dewatering System Upgrade	Level 3	2	2
ECM 7: Lighting System Upgrade	Level 1	n/a	0.5
ECM 9: Near-Term Dewatering Improvement	Level 3	2	2
ECM 10: MyEnergyPro™	Level 1	2	n/a

7.3 Performance Period Commissioning Plan

Commissioning activities during the performance period will coincide with annual M&V on-site activities and will vary by measure. In general, on-site activities will include interviews with on-site maintenance personnel responsible for the equipment, reviews of maintenance records and a visual inspection of the equipment. Variations in equipment and/or operation that are, or potentially could be, negatively affecting system performance will be noted in an annual report to TMWRF.

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8.0 Operations and Maintenance Plan

A well-designed and properly executed maintenance program is a crucial element to long-term ECM performance and savings. In order to maximize the energy savings and equipment performance, the ECMs should be maintained under an ongoing, structured service program for the life of the contract, and ideally beyond. Ameresco has a vested interest in the equipment performance and maintenance required to realize all possible energy savings, which form the basis of our guarantee.

Table 8.1 provides a summary of the O&M responsibilities for this project. For the majority of the ECMs, TMWRF will use internal staff to operate and maintain the system, or directly hire third party contractors. We do not recommend Ameresco provide the O&M services, to minimize the costs to TMWRF. Ameresco will provide maintenance services for the MyEnergyPro™ software suite for the performance period.

Details of the O&M requirements for the new systems will be included in the O&M manual following construction, and will be provided to TMWRF at project acceptance.

Ameresco will provide a one year guarantee on materials and labor for the project from the start of the performance period. Equipment manufacturers will provide additional warranties on respective equipment. Warranty forms will be provided to TMWRF with the O&M manual.

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Table 8.1. Operations and Maintenance Matrix

ECM Description	Ameresco Operations Responsibilities	TMWRF Operations Responsibilities	Ameresco Maintenance Responsibilities	TMWRF Maintenance Responsibilities	Warranty
ECM 2: Centrate Nutrient Recovery	None.	Ostara will remotely monitor and optimize operations of the Pearl system. TMWRF will provide field operation services such as daily inspection, fertilizer harvesting, truck loading, etc.	None.	TMWRF will perform routine and preventive maintenance services for the system as specified in the O&M manual.	Minimum one year warranty on the system.
ECM 4A: Biogas Cogeneration System	None.	TMWRF will provide field operation services as specified by engine manufacturer.	None.	TMWRF will provide preventive maintenance every 2,000 ophs hours as specified by manufacturer. TMWRF will hire manufacturer’s local vendor to perform routine maintenance at 10,000 ophs hours and major overhauls at 60,000 ophs hours.	Engine warranty will be 12 months after start up and commissioning, or 8,000 ops hours, or a maximum of 18 months after delivery from manufacturer’s facility, whichever is the earliest.
ECM 4B: Digester Domes Rehabilitation	n/a	n/a	n/a	n/a	Minimum one year warranty.
ECM 6: Dewatering System Upgrade	None.	TMWRF will perform services to run the centrifuges and cake pumps for routine treatment process operation.	None.	TMWRF will hire local centrifuge and cake pump vendors to perform preventive and routine maintenance on the equipment.	Centrifuge manufacturer provides a 24 month warranty from shipment date, or 18 months from start up and acceptance, whichever occurs first. Cake pump manufacturer provides a 2 year warranty on the equipment.

Table 8.1. Operations and Maintenance Matrix

ECM Description	Ameresco Operations Responsibilities	TMWRF Operations Responsibilities	Ameresco Maintenance Responsibilities	TMWRF Maintenance Responsibilities	Warranty
ECM 7: Lighting System Upgrade	None.	None.	None.	TMWRF will perform routine fixtures cleaning and replacements of the lamps, ballasts, and controls.	Minimum 2-year warranty on all lamps, and a minimum of 5-year warranty on ballasts. Manufacturer provides a 5-year limited warranty on wall and ceiling occupancy sensors.
ECM 9: Near-Term Dewatering Improvement	None.	TMWRF will provide services to run the dewatering facility for routine treatment process operation.	None.	TMWRF will perform preventive and routine maintenance on the polymer system.	Minimum one year warranty on the system.
ECM 10: MyEnergyPro™	None.	None.	Ameresco will maintain the software services for the performance period.	None.	n/a

8.1 ECM 2: Centrate Nutrient Recovery

Operations and maintenance of the Pearl system will be shared between TMWRF and Ostara. On the operation side, Ostara will focus on optimizing process performance and fertilizer production, while TMWRF will focus on equipment oversight and nutrient recovery operation within the wider plant processes.

More detailed descriptions of the proposed shared O&M responsibilities as provided by Ostara is included in the Appendix. These preliminary O&M requirements will be adjusted accordingly during construction.

As directed by TMWRF, Ameresco has included a budget for annual O&M of this ECM in the cash flow. For routine operations and maintenance, we estimated that TMWRF will require 0.4 full time employee (FTE) to perform the work. Costs for parts, replacements, and other general maintenance are also included in the budget. This annual budget will be taken from the savings stream, and will ensure that TMWRF will be able to perform O&M for the system as necessary to maintain the savings.

Total annual O&M budget = $54,000

Budget for 0.4 FTE = $32,000

Budget for general maintenance = $22,000

8.2 ECM 4A: Biogas Cogeneration System

TMWRF will be responsible to operate the biogas cogen engine and the overall heat recovery system. Not much operational work is anticipated for the engine aside from daily inspection to ensure the engine runs normally. The engine operation will be highly automated with little operator input.

Sample maintenance requirements of the engine are provided in the Appendix. For preventive maintenance (PM) of the engine every 2,000 operations hours (oph), Ameresco recommends that TMWRF performs the labor internally and buys the parts from the local vendor. However, for the larger routine maintenance (RM) every 10,000 oph, we recommend TMWRF hires the local vendor to perform the work. The engine requires a major overhaul every 60,000 ophs, and for this work we also recommend TMWRF hire the local vendor.

For this ECM, TMWRF directed Ameresco to include the O&M costs in the cash flow to ensure there is budget for maintaining the engine. Since the O&M requirement is not the same every year, the budget is an annualized cost over the 15 year performance period. Breakdown of the O&M costs were described in Section 4, and are repeated here.

Total annual O&M budget = $127,719

Annual TMWRF labor cost = $14,600

Annualized PM cost = $ 8,937

Annualized RM cost = $63,886

Annualized major overhaul cost = $40,296

8.3 ECM 4B: Digester Domes Rehabilitation

The digester domes rehabilitation ECM is included in the project to address the gas leak issue that TMWRF was having during the audit. As the domes are of fixed-cover type, they have no moving parts. Consequently, we do not anticipate any operations or maintenance needs for the domes. We recommend TMWRF schedule a regular visual inspection of the domes for signs of leaks or structural damage.

8.4 ECM 6: Dewatering System Upgrade

TMWRF will be responsible for operating the new centrifuges and cake pumps to dewater the sludge as part of the wider treatment process operation. For the most part, the system will be automated and require little operator input to run. TMWRF may need to adjust operating parameters of the equipment to satisfy the overall treatment process requirements.

Maintenance for the new centrifuges and cake pumps will follow the guidelines provided by the manufacturers. Sample O&M manuals for the centrifuges and cake pumps are too large to be included in the Appendix; instead, they are provided as electronic files with this FGOA report. The sample O&M manuals contain the detailed maintenance requirements for the equipment, and are summarized on the following page. As with the biogas cogen engine, we recommend TMWRF perform the preventive maintenance internally, but hire local equipment vendors to perform the major services.

Table 8.2. Schwing Bioset Cake Pump O&M Summary

O&M Type	Maintenance	Frequency
Preventive Maintenance	Replace hydraulic filters (2)	Every 2,000 oph
	Replace oil filters (2)	
	Replace material rams	
	Replace suction seats	
	Replace discharge seats	
Routine Maintenance	All items on PM list	Every 8 years
	Replace seals	
	Replace bushings	

Table 8.3. Alfa-Laval ALDEC G2 Centrifuge O&M Summary

Component	Maintenance	Frequency
Gearbox	Oil leakage check	Monthly
Gearbox	Oil level check	1,000 oph
Gearbox	Oil change	2,000 oph
Gearbox Spline Shaft	Lubricate splines	At each major service
Motor(S)	Lubrication	2,000 oph
V-Belts	Tightening and check	2,000 oph
V-Belts	Replace	16,000 oph
Bowls	Check for wear and corrosion	1,000 oph
Solids Discharge	Check for wear, replace	1,000 oph
Safety Equipment	Check functions	2,000 oph
Foundation Bolts	Check tightening	4,000 oph
Vibration Dampers	Check, replace as necessary	4,000 oph

For this ECM, existing dewatering equipment at the plant will be replaced with equipment of the same type. Existing horizontal bowl centrifuges will be replaced with new horizontal bowl centrifuges, and existing cake pumps will be replaced with new cake pumps. Because of this in-kind replacement, we anticipate that the O&M burden for the new equipment will be similar to TMWRF's existing O&M burden. As such, we have not included an additional O&M budget for this ECM in the cash flow.

8.5 ECM 7: Lighting System Upgrade

The new lighting system will have the same operation as the existing system, and there is no specific requirement for TMWRF in terms of operations. TMWRF will need to replace the lamps and ballasts as they burn out, as is done currently. Because the new lamps and ballasts have longer lives than the existing lamps and ballasts, we project that it will cost less annually for TMWRF to maintain the equipment. This O&M material savings is included in the cash flow, and the calculation is included in the Appendix. We did not include the labor component of this O&M savings, per State requirement.

8.6 ECM 9: Near Term Dewatering Improvement

As with the new centrifuges and cake pumps, O&M requirements for the new polymer system and other components in this ECM will be part of the larger operations of the treatment plant. TMWRF will need to adjust parameters of the polymer system to ensure optimal dewatering operation. New and additional HVAC equipment will be commissioned after installation, and will have automated controls for their operation.

Maintenance requirements for the polymer system will be similar to TMWRF's existing polymer injection system. TMWRF will be responsible for refilling the polymer tanks as it is consumed. TMWRF will need to maintain the polymer aging system and the transfer pumps. Polymer injection rings at the cake transfer pipes will need to be maintained to ensure proper lubrication. The new exhaust fans, ventilation fans, and other new HVAC system will have similar maintenance requirements as the HVAC systems in other buildings.

Ameresco did not include an O&M budget for this ECM in the cash flow because the requirements will be similar to TMWRF's existing O&M requirements for polymer system.

8.7 ECM 10: MyEnergyPro™

MyEnergyPro™ is a suite of software tools that will enable TMWRF to track utility use at the plant. The software will be web-based, and TMWRF will be provided with login information to access it from anywhere. Once the data collection system is set-up, there is no O&M required from TMWRF. Ameresco will maintain the server and web access to the software for the duration of the performance period.

Appendices

Appendices A-J are provided as follows:

Appendix A:	Energy Price Indices
Appendix B:	NV Energy SureBet Incentive Program
Appendix C:	List of Process Equipment
Appendix D:	ECM 2 Calculations and Datasheets
Appendix E:	ECM 4A Calculations and Datasheets
Appendix F:	ECM 4B Calculations and Datasheets
Appendix G:	ECM 6 Calculations and Datasheets
Appendix H:	ECM 7 Calculations and Datasheets
Appendix I:	ECM 9 Calculations and Datasheets
Appendix J:	ECM 10 Calculations and Datasheets

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Appendix A: Energy Price Indices

Please reference Appendix A for the 2013 Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis published by the National Institute for Standards and Testing (NIST).

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Appendix B: NV Energy SureBet Incentive Program

Please reference Appendix B for an overview of NV Energy's SureBet Incentive Program applicable to northern Nevada.

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Appendix C: List of Process Equipment

Please reference Appendix C for TMWRF's list of process equipment.

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Appendix D: ECM 2 Calculations and Datasheets

Please reference Appendix D for the following back-up documents in support of ECM 2: Centrate Nutrient Recovery:

- D-1: ECM 2 Datasheets Calculations
- D-2: Preliminary Diagrams
- D-3: Preliminary Utility Tie-ins
- D-4: Ostara Brochure
- D-5: Pearl Process Brochure
- D-6: Crystal Green QA-QC Process
- D-7: Sample O&M Document
- D-8: Ostara Pilot Report

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Appendix E: ECM 4A Calculations and Datasheets

Please reference Appendix E for the following back-up documents in support of ECM 4A: Biogas Cogeneration System:

- E-1: ECM 4A Datasheets Calculations
- E-2: Preliminary Diagrams
- E-3: GE Jenbacher Brochure
- E-4: GE Jenbacher Schematic
- E-5: GE Jenbacher Technical Description
- E-6: GE Jenbacher Fuel Quality TI 1000-0300
- E-7: Sample O&M Document
- E-8: Sample Preventative Maintenance Agreement

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Appendix F: ECM 4B: Digester Domes Rehabilitation

Please reference Appendix F for the following back-up document in support of ECM 4B: Digester Domes Rehabilitation:

- F-1: Brown Caldwell Digester No. 3 Cover Assessment

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Appendix G: ECM 6: Dewatering System Upgrade

Please reference Appendix G for the following back-up documents in support of ECM 6: Dewatering System Upgrade:

- G-1: ECM 6 Datasheets Calculations
- G-2: Alfa Laval Centrifuge Brochure
- G-3: Alfa Laval Centrifuge Schematic
- G-5: Schwing Bioset Cake Pump Brochure

The following documents can be found as electronic files on the attached CD:

- G-4: Centrifuge Sample O&M Document
- G-6: Schwing Bioset Sample O&M Document

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Appendix H: ECM 7: Lighting System Upgrade

Please reference Appendix H for the following back-up documents in support of ECM 7: Lighting System Upgrade:

- H-1: Rooms Lighting List
- H-2: Rooms Lighting List
- H-3: Lighting O&M Savings

The following documents can be found as electronic files on the attached CD:

- H-4: Lighting Materials Cutsheets

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Appendix I: ECM 9: Near Term Dewatering Improvement

The following documents can be found as electronic files on the attached CD in support of ECM 9: Near Term Dewatering:

- I-1: CH2MHILL Near Term Dewatering Improvement Project
- I-2: Specifications for CH2MHILL Near Term Dewatering Improvement Project

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Appendix J: ECM 10: MyEnergyPRO™

Please reference Appendix J for the following back-up documents in support of ECM 10: MyEnergyPro:

- J-1: UtilityPRO Brochure
- J-2: DashPRO Brochure

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