MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION FOR ITHACA AREA WASTEWATER TREATMENT FACILITY

Agreement No. 7185

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TABLE OF CONTENTS

Section Page

1 INTRODUCTION 1-1
1.1 Overall Project Description 1-1
1.2 Facility Background 1-1
1.3 Scope and Objectives 1-2
1.3.1 Review of Historical Plant Performance and Energy Usage Data 1-2
1.3.2 Electric Submetering 1-3
1.3.3 Identification of Energy Saving Opportunities through Equipment Replacement or Modification 1-4
1.3.4 Identification of Energy Saving Opportunities through Operational Changes 1-4

2 CURRENT AND HISTORICAL OPERATIONS 2-1
2.1 Existing Treatment Processes 2-1
2.1.1 Preliminary Treatment 2-1
2.1.2 Influent Wastewater Pumping 2-1
2.1.3 Primary Treatment 2-1
2.1.4 Secondary Treatment 2-2
2.1.5 Tertiary Treatment 2-2
2.1.6 Chlorine Disinfection 2-2
2.1.7 Solids Handling 2-2
2.2 Historical Energy Usage and Utility Billing 2-3
2.3 Natural Gas Usage 2-4
2.4 Summary of Energy Costs 2-4
2.5 Summary of Historical Loadings and Effluent Quality 2-5

3 ELECTRIC SUBMETERING PROGRAM 3-1
3.1 Description of Submetering Program and Submeter Locations 3-1
3.1.1 Description of Program 3-1
3.1.2 Submeter Locations 3-1
3.2 Summary of Site Audit 3-2
3.3 Summary of Continuous Submetering 3-2
3.3.1 Digester-Gas Fueled Co-generators 3-2
3.3.2 Influent Pumps 3-3
3.3.3 Aeration System Blowers 3-4
3.3.4 Return Activated Sludge Pumps 3-4
3.3.5 Solids Handling Building Belt Filter Press 3-5
3.4 Summary of Instantaneous Submetering 3-5
3.5 Summary of Entire Submetering Program 3-6

4 PROCESS PERFORMANCE DURING SUBMETERING 4-1
4.1 Summary of Process Performance Parameter Monitoring 4-1
4.2 Relationship between Plant Process Data and Submetering Data 4-2
4.2.1 Main Influent Wastewater Pumps 4-2
4.2.2 Return Activated Sludge Pumps 4-3
4.2.3 Aeration Blowers 4-3
4.2.4 Solids Handling 4-4
4.2.5 Digester Gas Co-Generator 4-4

TABLE OF CONTENTS (continued)

Section Page

4.2.6 Other Equipment 4-5

5 ENERGY SAVING MEASURES THROUGH CAPITAL IMPROVEMENTS 5-1
5.1 Capital Improvement Alternatives to Reduce Energy Usage and Costs....5-1
5.1.1 Installation of Automatic Controls on the Aeration System Blowers....5-1
5.1.2 Switching from Ferrous Chloride Use for Phosphorus Removal in the Aeration Basins....5-1
5.2 Estimate of Energy Usage, Demand, and Cost Savings 5-1
5.2.1 Installation of Automatic Controls on the Aeration System Blowers....5-2
5.2.2 Switching from Ferrous Chloride to Ferric Chloride Use for Phosphorus Removal in the Aeration Basins 5-3
5.3 Estimate of Capital Costs and Simple Payback....5-4
5.3.1 Installation of Automatic Controls on the Aeration System Blowers....5-4
5.3.2 Conversion from Ferrous Chloride to Ferric Chloride Use for Phosphorus Removal in the Aeration Basins 5-4
5.4 Additional Discussion: Premium Efficiency Motors 5-4

6 ENERGY SAVINGS MEASURES THROUGH OPERATION MODIFICATIONS 6-1
6.1 Operational Modifications to Reduce Energy Usage....6-1
6.1.1 Load Shifting....6-1
6.1.2 Peak Shaving 6-2
6.1.3 Operational Modifications 6-3

7 ENERGY SAVINGS MEASURES THROUGH LIGHTING/HVAC MODIFICATIONS....7-1
7.1 Overview....7-1
7.1.1 Heating, Ventilating, and Air Conditioning Overview....7-1
7.1.2 Lighting Overview 7-2
7.2 HVAC and Lighting Alternatives to Reduce Energy Usage and Costs....7-2
7.2.1 Heating, Ventilation, and Air Conditioning 7-2
7.2.2 Lighting....7-2

8 ON-SITE GENERATION 8-1
8.1 Description of Existing System Operation....8-1
8.2 Capital Improvement Alternatives 8-2
8.2.1 Alternative 1 Evaluation: Installation of Gas Storage Facilities and New Controls with Continued Operation of the Existing Co-Generator Units....8-2
8.2.2 Alternative 2 Evaluation: Installation of Gas Storage Facilities and New Controls and Replacement of the Co-Generator Units with Microturbines 8-3
8.2.3 Alternative 3 Evaluation: Installation of Gas Storage Facilities and Upgraded Heat Recovery and Controls; In-Kind Replacement of the Existing Co-Generator Units with Higher-Efficiency Recriprocating Engines 8-4
8.3 Load Curtailment....8-5
8.4 Summary....8-5

TABLE OF CONTENTS (continued)

Section — Page

9 FINAL RECOMMENDATIONS 9-1
9.1 Summary of Evaluations 9-1
9.2 Summary of Recommendations 9-1

TABLES

Table — On/Follows Page

2-1 Summary of Energy Costs 2-5
2-2 Summary of North Plant Performance – Wet Stream Process 2-5
2-3 Summary of North Plant Performance – Solids Handling Processes 2-7

3-1 List of Motors Over 5 hp 3-1
3-2 Instantaneous Power Draw Measurements and Estimates of Hours in Operation 3-5
3-3 Estimates of Electric Energy Usage and Costs 3-5
3-4 Summary of Major Equipment Total Estimated Electric Energy Usage and Costs at the IAWWTF 3-6

4-1 Summary of IAWWTF Performance during the Submetering Period Compared To Historical Data 4-2

7-1 Summary of Costs and Savings for HVAC Measures 7-2
7-2 Summary of Costs and Savings for All Lighting Measures 7-3

8-1 Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls with Existing Co-Generator Units 8-3
8-2 Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls and Replacement of the Co-Generator Units with Microturbines 8-4
8-3 Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls and In-Kind Replacement of the Co-Generator Units with Higher Efficiency Reciprocating Engines 8-4

9-1 Summary of Energy Savings Alternatives Presented in 5, 6, 7, and 8 9-1
9-2 Summary of Recommended Alternatives 9-1

FIGURES

Figure — Follows Page

2-1 Process Flow Scheme 2-1
2-2 Electric Demand and Usage 2-3
2-3 Change in Electric Demand (2002 – 2003) 2-3
2-4 Change in Electric Usage (2002 – 2003) 2-3
2-5 Natural Gas Usage (2002 – 2003) 2-4
2-6 Influent TSS and BOD_5 Loading 2-6

TABLE OF CONTENTS (continued)

FIGURES (Continued)

Figure		Follows Page
2-7	Electric Demand vs. Average Plant Flow	2-6
2-8	Electric Usage vs. Average Plant Flow	2-6
2-9	Natural Gas Usage vs. Average Plant Flow	2-6
2-10	Monthly Digester Gas Production vs. Average Plant Flow	2-6
3-1	Submetering – Digester Gas Fueled Co-Generators 1 and 2	3-2
3-2	Submetering – Influent Pumps 1 and 2	3-3
3-3	Submetering – Aeration System Blowers 1 and 2	3-4
3-4	Submetering – RAS Pumps 2 and 5	3-4
3-5	Submetering – Belt Filter Press	3-5
3-6	Distribution of Electric Energy Usage Among Processes	3-7
3-7	Distribution of Electric Energy Usage Among Solids Handling Processes	3-7
4-1	Submetering – BOD_5 vs. Plant Flow	4-1
4-2	Submetering – BOD_5 Loading vs. Plant Flow	4-1
4-3	Submetering – TSS vs. Plant Flow	4-1
4-4	Submetering – TSS Loading vs. Plant Flow	4-1
4-5	Average Daily Flow vs. Total Electric Demand by Influent Pumps	4-3
4-6	Average Daily Flow vs. Total Electric Demand by RAS Pumps	4-3
4-7	Aeration Tank Delivered Air Flow vs. Total Electric Demand by Aeration Blowers	4-3
4-8	Aeration Tank Dissolved Oxygen vs. Delivered Air Flow	4-3
4-9	Aeration Tank Dissolved Oxygen vs. Primary Effluent BOD_5 Loading	4-3
4-10	Aeration Tank Dissolved Oxygen vs. Delivered Air Flow	4-4
4-11	Percent Solids vs. Total Electric Demand by Belt Filter Press	4-4
4-12	Belt Filter Press Loading vs. Total Electric Demand by Belt Filter Press	4-4
4-13	Total Gas Production vs. Total Electric Energy produced by Cogenerators	4-5
5-1	Aeration Blower Performance Curve	5-2
6-1	Electric Energy Demand Submetered Equipment	6-1

Section 1
INTRODUCTION

1.1 OVERALL PROJECT DESCRIPTION

The New York State Energy Research and Development Authority (NYSERDA) is currently sponsoring a research program to evaluate submetering at wastewater treatment plants (WWTPs) throughout New York State. The purpose of the monitoring is to obtain detailed electric power usage information through submetering various unit processes and equipment and to determine if that information is a cost-effective tool for identifying energy conservation measures. In addition to evaluating the usefulness of submetering, a secondary goal of the program is to identify and evaluate energy cost savings measures at WWTPs and make the findings available to other facilities in New York State.

Although the City of Ithaca has been proactive in implementing energy-saving measures at its Ithaca Area Wastewater Treatment Facility (IAWWTF), energy-saving opportunities may still exist. Therefore, the City of Ithaca agreed to participate in this submetering study as conducted by the Research Team of Malcolm Pirnie and Siemens Building Technology.

1.2 FACILITY BACKGROUND

The IAWWTF was built in the mid-1980s and serves the City and Town of Ithaca, including Cornell University and Ithaca College. There is only one significant industrial user: Emerson Power Transmission Corporation. The remainder of the wastewater is residential; however, wastewater flow does include discharge from Cornell University. Discharge from Cornell University varies based on the school schedule, with the number of students on campus increasing significantly in late-August and early-September. The IAWWTF handled an average wastewater flow of 6.8 million gallons per day (MGD), peaking up to 16.7 MGD during 2002 and 2003.

The IAWWTF is fed electric power at 13.2 kilovolts (kV), which is immediately stepped down to 480 volts (V) three phase. The electric energy demand at the plant is approximately 450 kilowatts (kW) on average. The facility has one 800-kW stand-by generator powered by diesel fuel. The generator is located immediately next to the substation and has sufficient capacity to power the entire plant, if necessary.

The treatment processes at the IAWWTF include the following:

- Preliminary treatment, including mechanically-cleaned bar screens.
- Primary clarification.

- Secondary biological treatment with activated sludge aeration followed by final clarification.
- Disinfection using sodium hypochlorite.
- Dechlorination using sulfur dioxide gas.
- Solids handling consisting of sludge thickening (gravity thickeners), digestion, and sludge dewatering using a belt filter press, followed by landfilling.

The City is voluntarily installing tertiary treatment facilities, based on the potential that the New York State Department of Environmental Conservation (NYSDEC) may impose more stringent effluent requirements for phosphorus removal in five to ten years. The tertiary treatment facility is a high-rate enhanced clarification system (Actiflo®).

1.3 SCOPE AND OBJECTIVES

This study involved the following activities as part of the overall electric and natural gas energy usage evaluation and electric submetering program:

1.3.1 Review of Historical Plant Performance and Energy Usage Data

Data were obtained from the IAWWTF to establish a baseline for plant performance and energy usage at the IAWWTF. The baseline was established to separate improvements related to power savings from those that result from exogenous effects, such as changes in influent water quality, seasonal, and weekly cycles, and/or energy market changes.

Data obtained from the IAWWTF included:

- Average, minimum, and maximum daily flow.
- Influent, primary effluent, and final effluent total suspended solids (TSS) and biochemical oxygen demand (BOD_5) concentrations.
- Mixed liquor suspended solids (MLSS).
- Primary sludge quantities.
- Return activated sludge (RAS) flow and solids content.
- Waste activated sludge (WAS) flow.
- Digester feed sludge quantities and total and volatile solids percentage.
- Digested sludge quantities and total and volatile solids percentage.
- Digester gas production.
- Historical electric energy usage, including available time-of-use monitoring data, two years of utility bills, and any process changes recently undertaken or contemplated.

- Recent energy consumption data for non-electric accounts, including natural gas, diesel and digester gas, etc.
- Preventive and corrective maintenance records.

1.3.2 Electric Submetering

Continuous submetering and instantaneous power draw measurements were completed to assess the typical electric energy usage of some of the larger motors (greater than 5 horsepower [hp]) at the IAWWTF. Continuous submetering locations were selected based on information gathered during the site energy audit such that the larger and more energy-intensive motors could be metered. Instantaneous power draw measurements were also obtained on additional motors, particularly those that operated on a set schedule at a constant speed.

The continuous submetering data were used to capture diurnal variations in electric energy demand for major pieces of equipment, as well as to provide a representative sample of electric energy usage and demand as equipment cycles on and off. The following data were recorded at each location:

- Load factor.
- Power factor.
- Demand (kW).
- Usage (kWh).

Instantaneous submetering was conducted during a one-day site visit and the data were used to verify expected energy demand at the facility, as well as monitor changes in demand as equipment is cycled on and off.

In addition, process data were collected and evaluated for the duration of the submetering period including:

- Aeration system operations.
- Digester gas fueled co-generator operations.

For the aeration system operations evaluation, data collected included:

- Secondary influent flow, in hourly increments.
- Secondary influent BOD_5 and ammonia concentrations, grab samples in bi-hourly increments (for 48 hours).

- Aeration basins dissolved oxygen (DO) concentrations, at hourly intervals.
- Blower airflow and pressure.

For the digester gas fueled co-generator operations evaluation, data collected included:

- Operating hours for the digester gas fueled co-generators.
- Digester gas production and usage (by co-generators and boilers).
- Electric energy production.

The process data collected were used to correlate electric energy usage to equipment operation and process performance, and to evaluate energy savings opportunities through equipment replacement or modification (Section 5) and through operational changes (Section 6). The data will also be used to establish basic energy performance measures (metrics) for comparison of energy usage at the IAWWTF to that of other WWTPs in New York State.

1.3.3 Identification of Energy Saving Opportunities through Equipment Replacement or Modification

Energy savings opportunities resulting from equipment replacement and/or process modification were identified based on a review of the submetering data. Although, some of these opportunities may consume more energy than existing processes, they may also serve to improve treatment at the plant, thereby saving operational dollars in the facility's overall budget.

1.3.4 Identification of Energy Savings Opportunities through Operational Changes

The submetering data were further reviewed to assess the impact of demand throughout the course of the day and examined for energy savings opportunities through load shifting, peak shaving, and greater use of real-time data in energy-related decision-making.

Load shifting involves changing the time of use of certain loads to reduce the total facility electric energy demand during peak periods in an attempt to reduce electric energy demand charges. Peak shaving is the practice of dispatching on-site generating assets to reduce dependence on the grid during peak electric energy demand periods. Existing on-site generating assets at the IAWWTF were evaluated to identify potential curtailable loads.

This report summarizes the data evaluation and offers recommendations for opportunities to reduce energy usage and thereby reduce costs at the IAWWTF.

Section 2
CURRENT AND HISTORICAL OPERATIONS

This section presents a brief description of the existing treatment processes at the Ithaca Area Wastewater Treatment Facility (IAWWTF), historical implementation of energy saving measures, and the resulting effect on effluent quality (if any).

2.1 EXISTING TREATMENT PROCESSES

FIGURE 2-1 presents the process flow diagram for the wet stream and solids handling process trains at the IAWWTF. A brief description of the unit treatment processes that are currently employed at the plant is presented below.

2.1.1 Preliminary Treatment

Preliminary treatment at the IAWWTF is accomplished through the use of two mechanically-cleaned bar screens. The bar screen rakes generally operate automatically once per hour. During higher flow rates, the rakes are manually set to operate more frequently.

2.1.2 Influent Wastewater Pumping

Wastewater enters the facility at the main pump building. There are five influent pumps in the main pump building, three of which have variable frequency drives (VFDs). The pumps are operated to maintain wet well level. During average flow conditions, only one pump with VFD is operated. During high flow conditions, two or three pumps with VFDs are operated (dependent on flow conditions). Flow conditions rarely occur where more than three pumps are required to be in operation at the same time.

2.1.3 Primary Treatment

Primary treatment consists of two rectangular primary settling tanks, each with approximately 1 million gallons (MG) of volume. There are three primary sludge pumps, each equipped with a VFD. During average flow conditions, two of the three pumps are typically operated. The grit removal facilities consist of a primary sludge degritter.

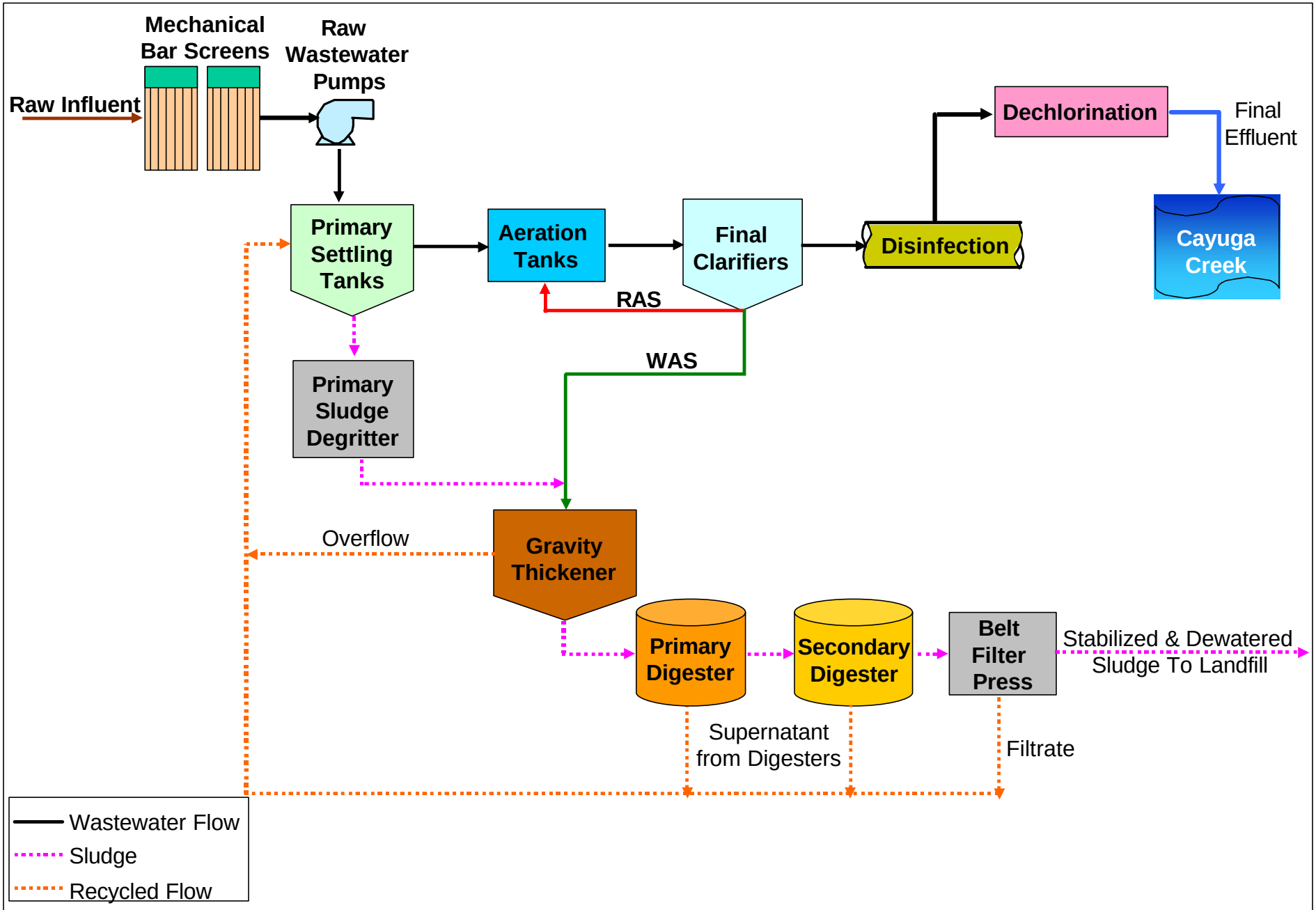

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FIGURE 2-1
PROCESS FLOW SCHEME

2.1.4 Secondary Treatment

Secondary treatment consists of four aeration basins, each having 0.5 MG of volume and a fine bubble diffuser system. There are four centrifugal blowers, each 125 horsepower (hp). Previously, dissolved oxygen (DO) probes automatically controlled the blowers. However, the blowers are now controlled manually by adjusting the blower inlets based on readings from the DO meters. The aeration basins are operated in plug flow mode.

From the aeration basins, wastewater continues to the final clarifiers. There are four rectangular final clarifiers, each with 0.5 MG of volume and fiberglass and plastic chain and flights. Settled sludge is either returned as returned activated sludge (RAS) to the aeration basins or wasted as waste activated sludge (WAS) to the gravity thickeners.

2.1.5 Tertiary Treatment

There are no tertiary facilities currently at the IAWWTF. However, because the City foresees that the New York State Department of Environmental Conservation (NYSDEC) may impose more stringent effluent phosphorus requirements for IAWWTF discharge in five to ten years, the City currently is voluntarily installing tertiary treatment facilities. The tertiary system under construction is Actiflo®, which is a high-rate clarification system that uses microsand-enhanced flocculation and settling.

2.1.6 Chlorine Disinfection

Disinfection occurs in the outfall pipe and uses 10% to 15% solution sodium hypochlorite. Dechlorination uses sulfur dioxide gas and is located in the dechlorination building approximately 2,400 feet north of the IAWWTF.

2.1.7 Solids Handling

Primary and secondary sludge is blended and pumped to two gravity thickeners. The thickened sludge is then pumped to the two digesters that operate as two-stage (in series). The primary digester has a volume of 1.3 MG and the secondary digester has a volume of 1.1 MG. Pearth gas mixing is used in both the primary and secondary digesters. The secondary digester is mixed once per week, so generally, it is stratified. Also, there is a floating gas cover on the secondary digester for digester gas storage. Digester gas is primarily used to run two co-generators, each 110-kilowatt (kW) capacity.

Digested sludge is pumped to the belt filter press. There is one 2-meter belt filter press that is operated five days per week (during the day shift only). Solids percentage into the press ranges between approximately 3% and 4%. Solids percentage leaving the press is 20% at a minimum to meet landfillng requirements, and typically averages 22%. In the summer, solids percentage peaks at approximately 24%. From the belt filter press, sludge cake is landfilled.

The IAWWTF is staffed from approximately 7:30 AM to 4:30 PM, five days per week (Monday through Friday), and from 7:30 AM to 3:00 PM on Saturday and Sunday. As the facility is equipped with panel alarms, it is not staffed in shifts.

2.2 HISTORICAL ENERGY USAGE AND UTILITY BILLING

A number of capital investment projects are either ongoing or have occurred in the past five years.

- A new belt filter press was installed in 2000.
- A fifth influent pump was installed in 2001.
- VFDs were installed on three influent pumps, three primary sludge pumps, one heat exchanger pump, two waste sludge pumps, three belt press feed pumps, and one belt press pump.
- One boiler has been rebuilt.
- Primary settling tank chains and flights replaced with plastic and fiberglass.

These projects are being/were implemented with the goals of improving the treatment processes and improving energy efficiency.

Monthly data on electric energy usage and billing (New York State Electric and Gas Corporation [NYSEG] and Advantage Energy) were obtained from the IAWWTF for 2002 and 2003, except May 2002 for which the data were unavailable. FIGURE 2-2 shows the monthly electric energy demand and usage for 2002 and 2003. Billing for the IAWWTF is based on the kW demand and kWh usage. The digester gas co-generators produce electric energy that is fed back into the facility's power grid for electric energy usage therefore reducing the billed usage.

The 2003 data set shows a slight decrease in electric energy demand and an increase in electric energy usage from the 2002 data set, with a decrease of 1.7% in average electric energy demand and a 2.8% increase in annual electric energy usage. It should be noted that the comparison of the electric energy demand and usage for the 2002 and 2003 dataset does not include the month of May 2002. FIGURES 2-3 and 2-4 illustrate the change in electric energy demand and usage, respectively, for 2002 through 2003. In combination with the electric rate increase, this resulted in a 7.9% increase in electric power charges (up

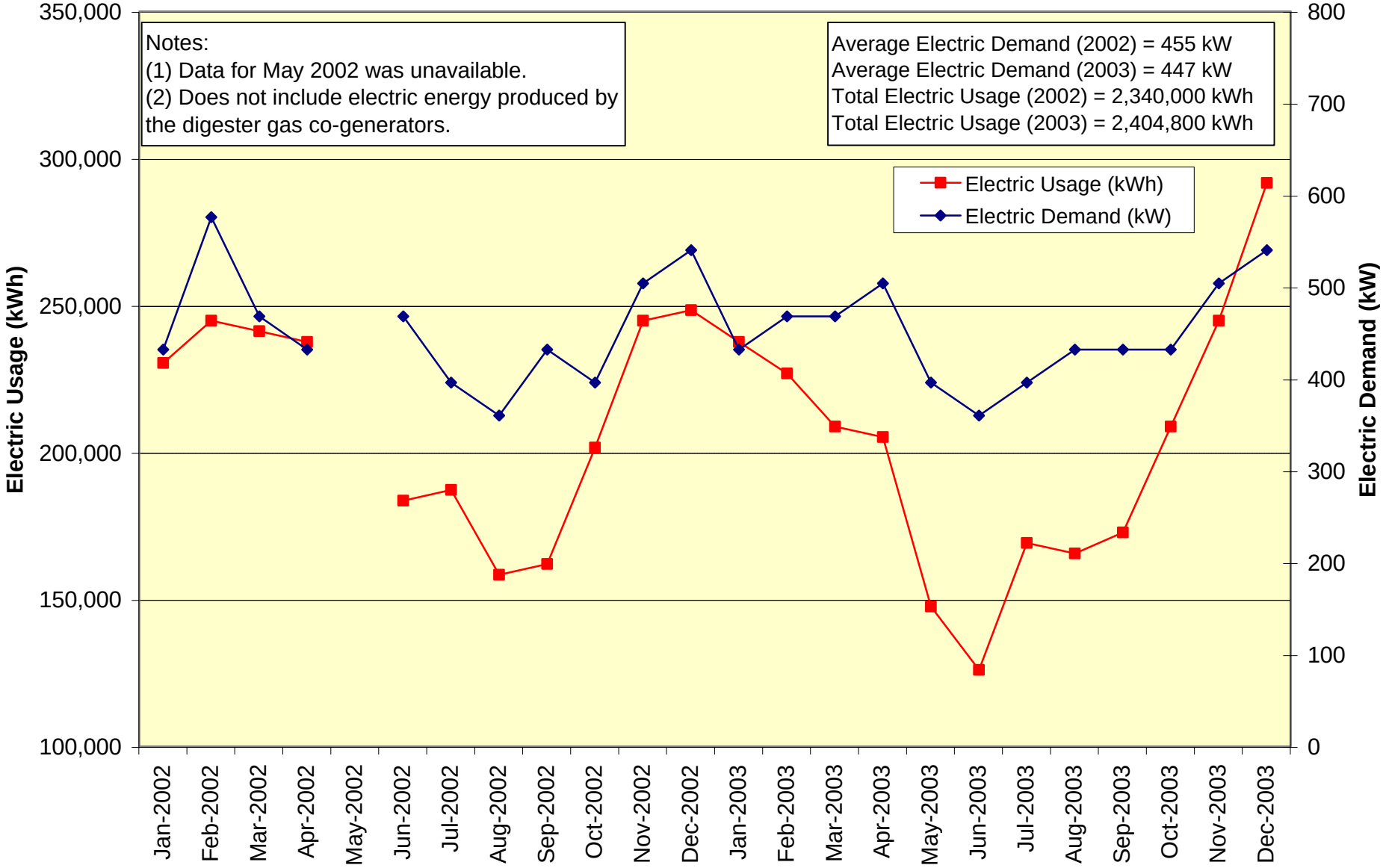

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FIGURE 2-2
ELECTRIC DEMAND AND USAGE
(2002 to 2003)

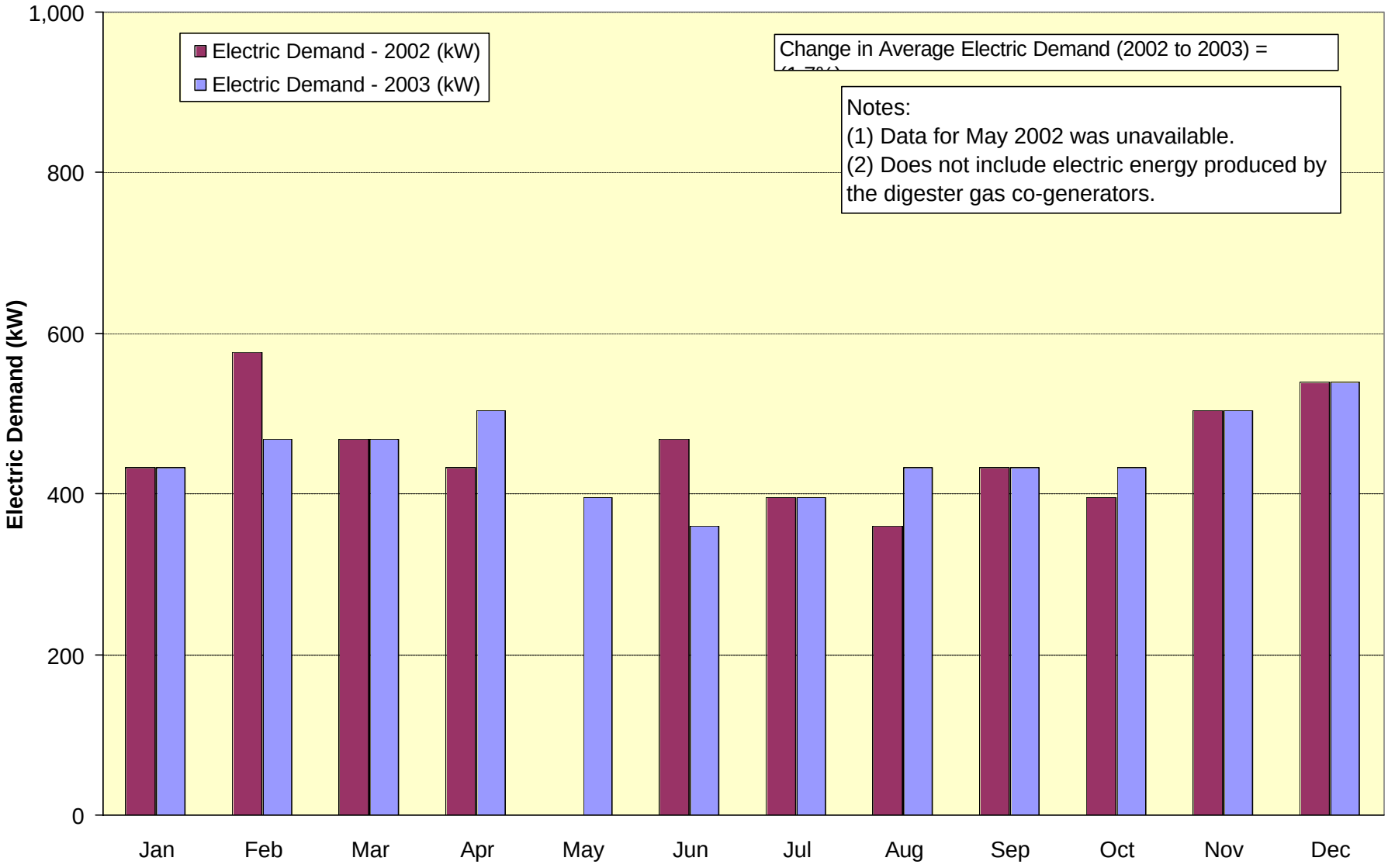

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FIGURE 2-3
CHANGE IN ELECTRIC DEMAND
(2002 to 2003)

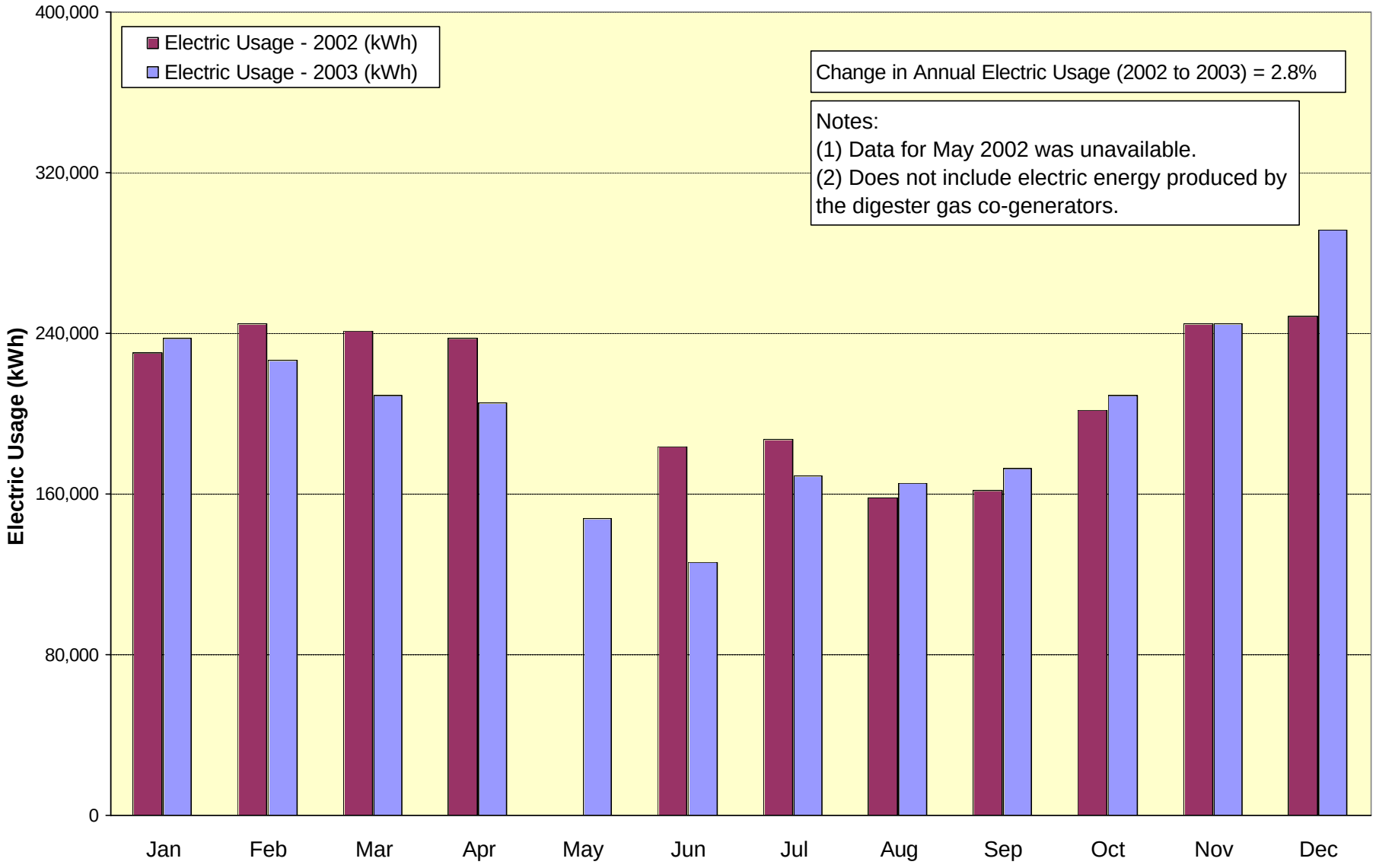

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FIGURE 2-4
CHANGE IN ELECTRIC USAGE
(2002 to 2003)

from $203,324 in 2002 at an average cost of $0.08 per kWh to $220,876 in 2003 at an average cost of $0.09 per kWh). However, it is noted that May 2002 electric energy demand, usage, and costs are missing and are not accounted for in the comparison. Hourly demand data are not available for the IAWWTF.

2.3 NATURAL GAS SUMMARY

FIGURE 2-5 shows a monthly comparison of natural gas usage and average temperatures for 2002 and 2003. Monthly data on natural gas usage and billing (NYSEG and Advantage Energy) were obtained from the IAWWTF for 2002 and 2003, except May 2002 which was not available. Average monthly temperatures were obtained from the National Weather Service-Binghamton, NY website. It can be seen that during winter months (lower temperature), the quantity of natural gas delivered was higher than in months with higher temperatures, as expected. The average temperature for 2002 was 47.2 degrees Fahrenheit (^{o}F) with a total usage of 128,684 therms at an average rate of $0.90 per therm and a total cost of $117,129. The average temperature for 2003 was 44.8 ^{o}F with a total usage of 139,842 therms at an average rate of $0.87 per therm and a total cost of $115,190. Due to a decrease in the natural gas rate, an 8.7% increase in the amount of natural gas delivered from 2002 to 2003 resulted in a 1.7% reduction in the total cost. However, it should be noted that the comparison of the monthly natural gas usage for the 2002 and 2003 dataset does not include the month of May 2002 as that data was unavailable. In addition to the natural gas usage, the generated digester gas is used to produce electric energy and used in boilers to heat the plant. It is seen on FIGURE 2-5 that even as the outdoor temperature increases during the months of February through April of both 2002 and 2003, there is also an increase in the natural gas usage. Plant staff indicated this may be related to annual digester maintenance performed in spring and reduced digester gas production during this time frame that contribute to increased natural gas usage.

Total plant natural gas usage on a per square foot basis can be calculated as a benchmark performance parameter by dividing the annual gas usage by the square footage of the buildings. The IAWWTF estimates that there is approximately 56,514 square feet of area spread over six buildings and six galleys. The estimated natural gas usage per square foot of the plant averaged approximately 2.3 therms per square foot in 2002 and 2.5 therms per square foot in 2003.

2.4 SUMMARY OF ENERGY COSTS

TABLE 2-1 summarizes the energy costs for 2002 and 2003 based on data provided by plant personnel.

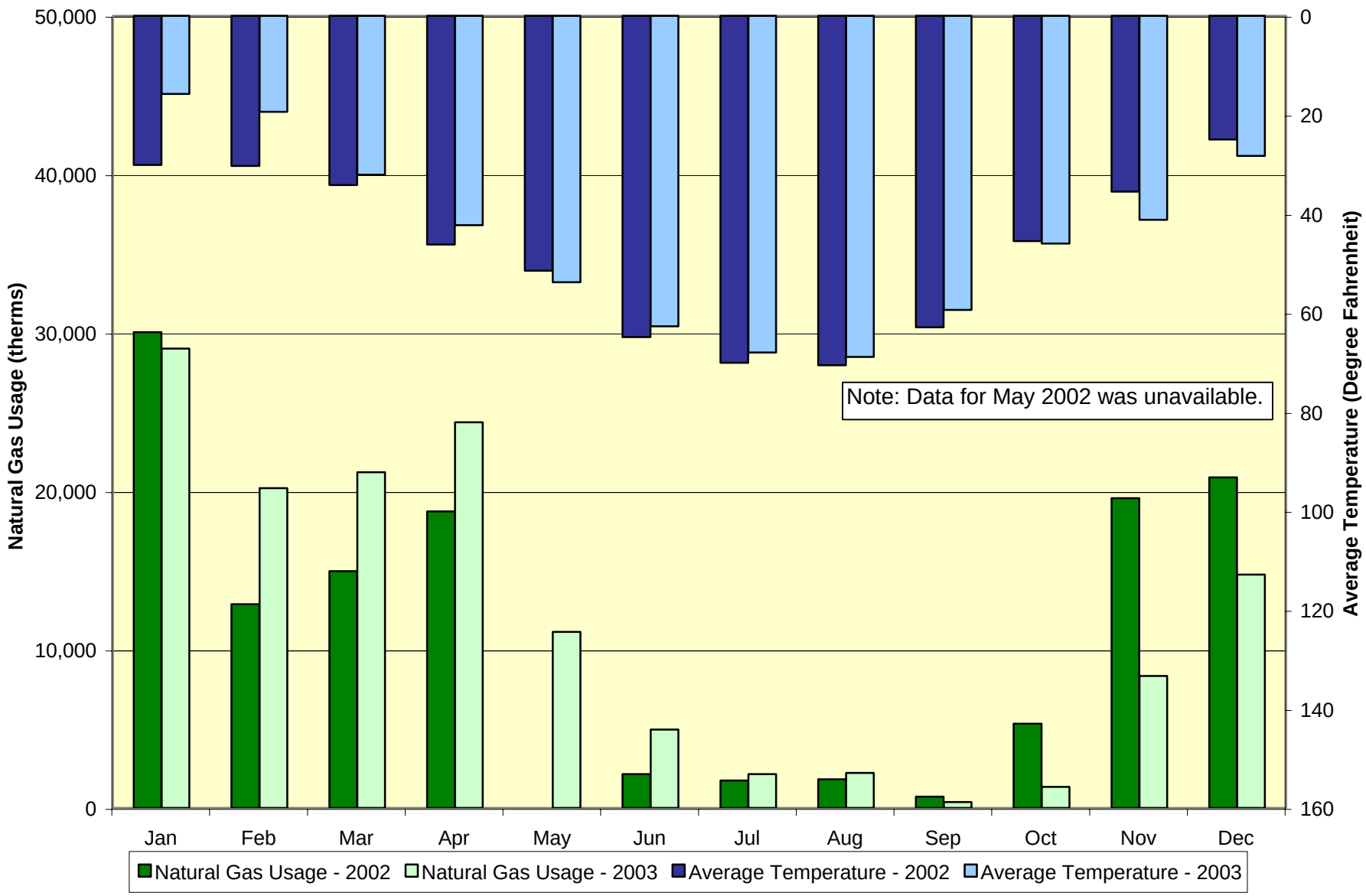

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FIGURE 2-5
NATURAL GAS USAGE
(2002 to 2003)

Table 2-1: Summary of Energy Costs

Year		2002	2003	Average
Average Flow (MGD)		6.48	7.03	6.75
Electricity	Annual Usage (kWh) - Billed	2,340,000	2,404,800	2,372,400
	Estimated Co-generator Production (kWh)	1,112,156	1,112,156	1,112,156
	Total Estimated Annual Usage (kWh)	3,452,156	3,516,956	3,484,556
	Rate ($/kWh) (1)	$0.08	$0.09	$0.09
	Annual Costs (1)	$203,324	$220,876	$212,100
	Average Usage (kWh per MG)	1,460	1,371	1,416
	Average Costs ($ per MGD) (1)	$85.99	$86.11	$86.05
Natural Gas	Annual Usage (Therms)	128,684	139,842	134,263
	Rate ($/Therms)	$0.90	$0.87	$0.88
	Annual Costs	$117,129	$115,190	$116,159
	Average Usage (Therms per MG)	54	55	55
	Average Costs ($ per MGD)	$49.54	$44.91	$47.22
Total Energy Costs of Electricity and Gas		$320,452	$336,066	$328,259
Total Energy Costs per MGD		$135.53	$131.02	$133.27

Note:
(1) Electric rates and costs are only for billed usage.

2.5 SUMMARY OF HISTORICAL LOADINGS AND EFFLUENT QUALITY

Monthly plant flows and process data provided by the IAWWTF for 2002 and 2003 is tabulated in TABLE 2-2.

Table 2-2: Summary of IAWWTF Performance – Wet Stream Process

Wastewater Parameter	Average	
	2002	2003
Influent Plant Flow (MGD)	6.48	7.03
Influent BOD_5 Concentration (mg/L)	194	178
Influent BOD_5 Loading (lb/d)	10,348	10,383
BOD_5 Removal (%)	92.6%	91.3%
Influent TSS Concentration (mg/L)	196	149
Influent TSS Loading (lb/d)	10,473	8,568
TSS Removal (%)	98.7%	98.4%

FIGURE 2-6 shows the relationship between influent BOD_5 and TSS loadings and plant flow. There does not appear to be a general trend in loadings with respect to flow. BOD_5 and TSS loadings do not appear to follow a seasonal pattern.

The IAWWTF has consistently achieved BOD_5 and TSS removal efficiencies in excess of 85% and effluent concentrations of both parameters are well below the monthly discharge permit limit of 30.0 milligrams per liter (mg/L) each.

In order to evaluate the electric energy usage at the IAWWTF, the electric energy usage and demand data were compared to IAWWTF flows to observe the effects of varying flows on electric energy usage. FIGURES 2-7 and 2-8 show the average monthly plant flows along with electric energy demand and usage, respectively. In general, there appears to be some correlation between the monthly plant flow and electric energy demand and usage.

FIGURE 2-9 shows the natural gas consumption along with IAWWTF flows. From FIGURES 2-9 and 2-5, it appears that the main factor influencing natural gas consumption is outdoor temperature. FIGURE 2-10 shows the monthly digester gas production along with IAWWTF flows. From the data it appears that there is no strong correlation between digester gas production and plant flows.

Based on the historical data, approximately 9,617 and 9,485 pounds of BOD_5 per day were removed for the years 2002 and 2003, respectively. Therefore, the estimated electric energy usage per pound of BOD_5 removed for 2002 and 2003 averages at approximately 1.0 kWh per pound of BOD_5 removed. Based on the historical data, approximately 10,357 and 8,443 pounds of TSS per day were removed for the years 2002 and 2003, respectively. Therefore, the estimated electric energy usage per pound of TSS removed for 2002 and 2003 averages at approximately 1.02 kWh per lb of TSS removed. The estimated natural gas usage per pound of BOD_5 removed averaged at approximately 0.039 therms per pound of BOD_5 removed.

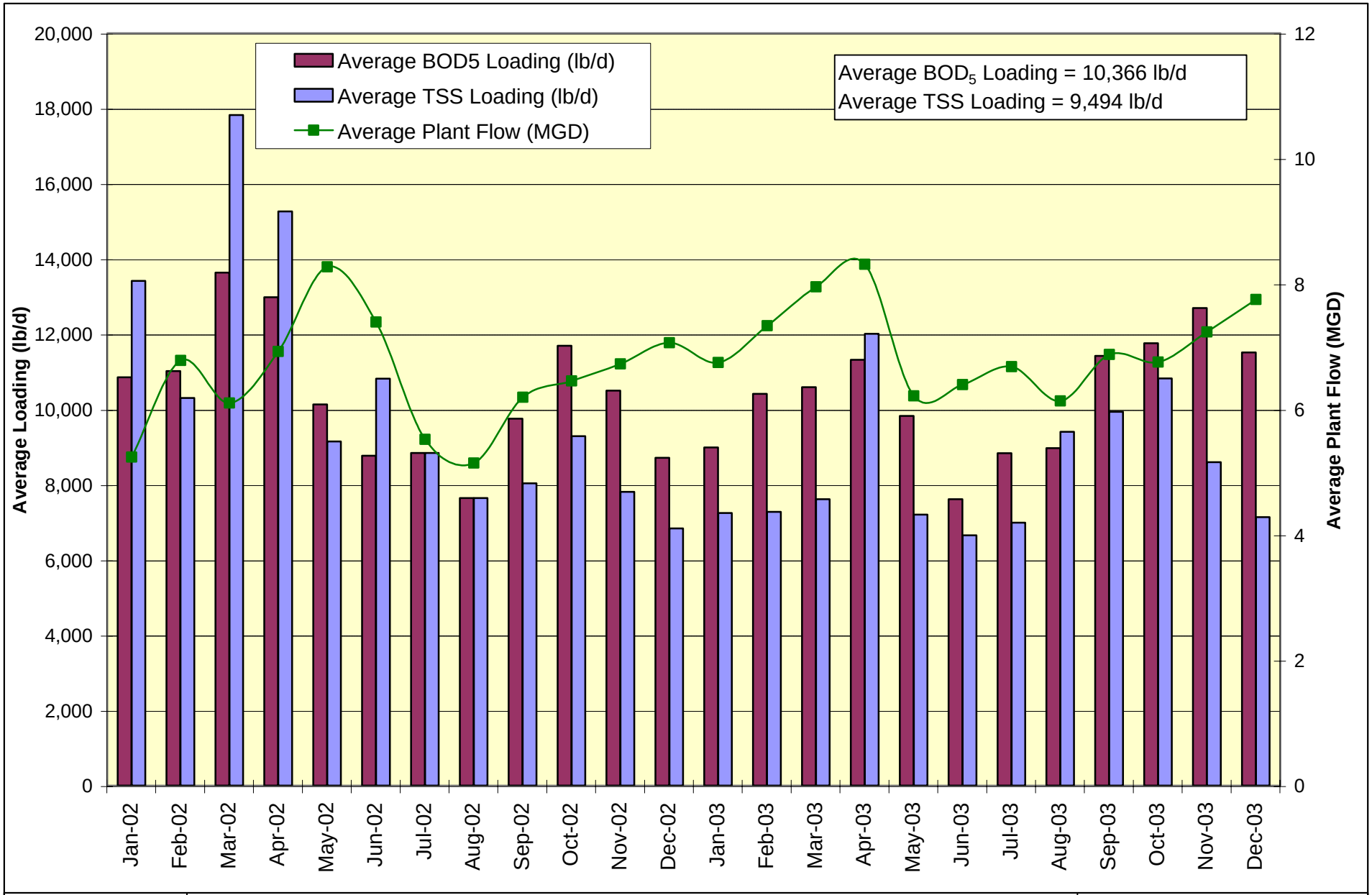

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FIGURE 2-6
INFLUENT TSS AND BOD_5 LOADING

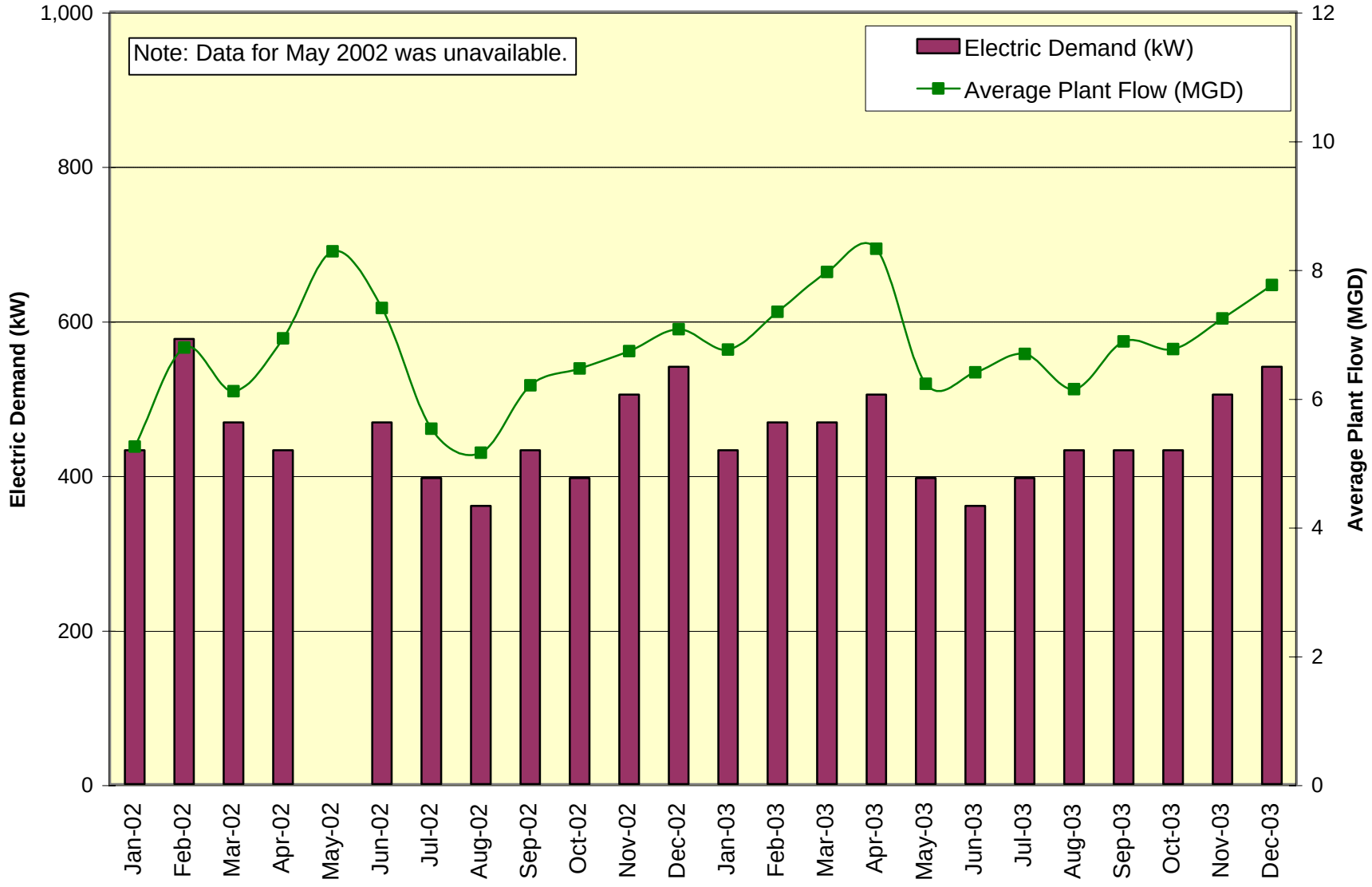

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FIGURE 2-7
ELECTRIC DEMAND vs
AVERAGE PLANT FLOW

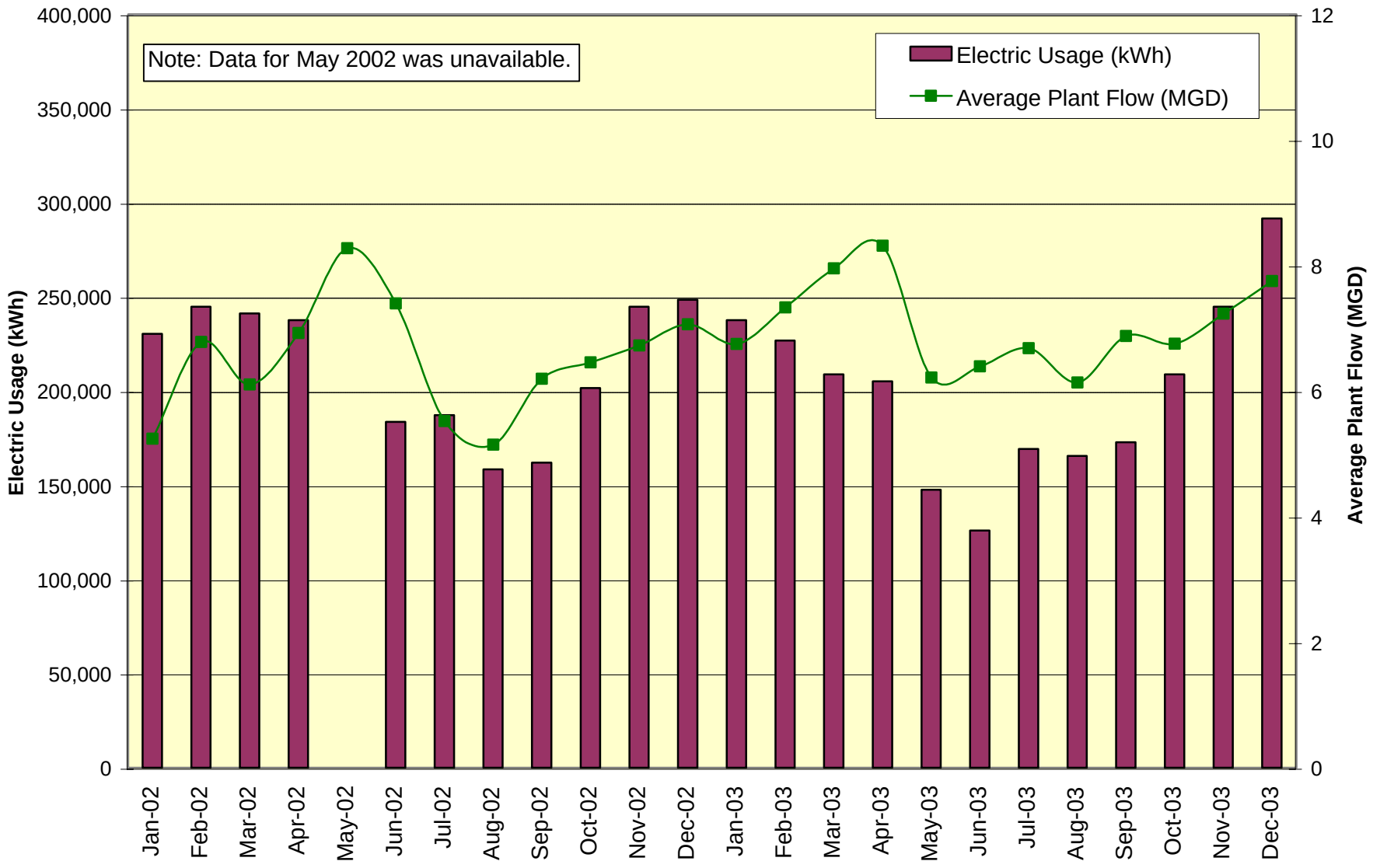

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FIGURE 2-8
ELECTRIC USAGE vs AVERAGE PLANT FLOW

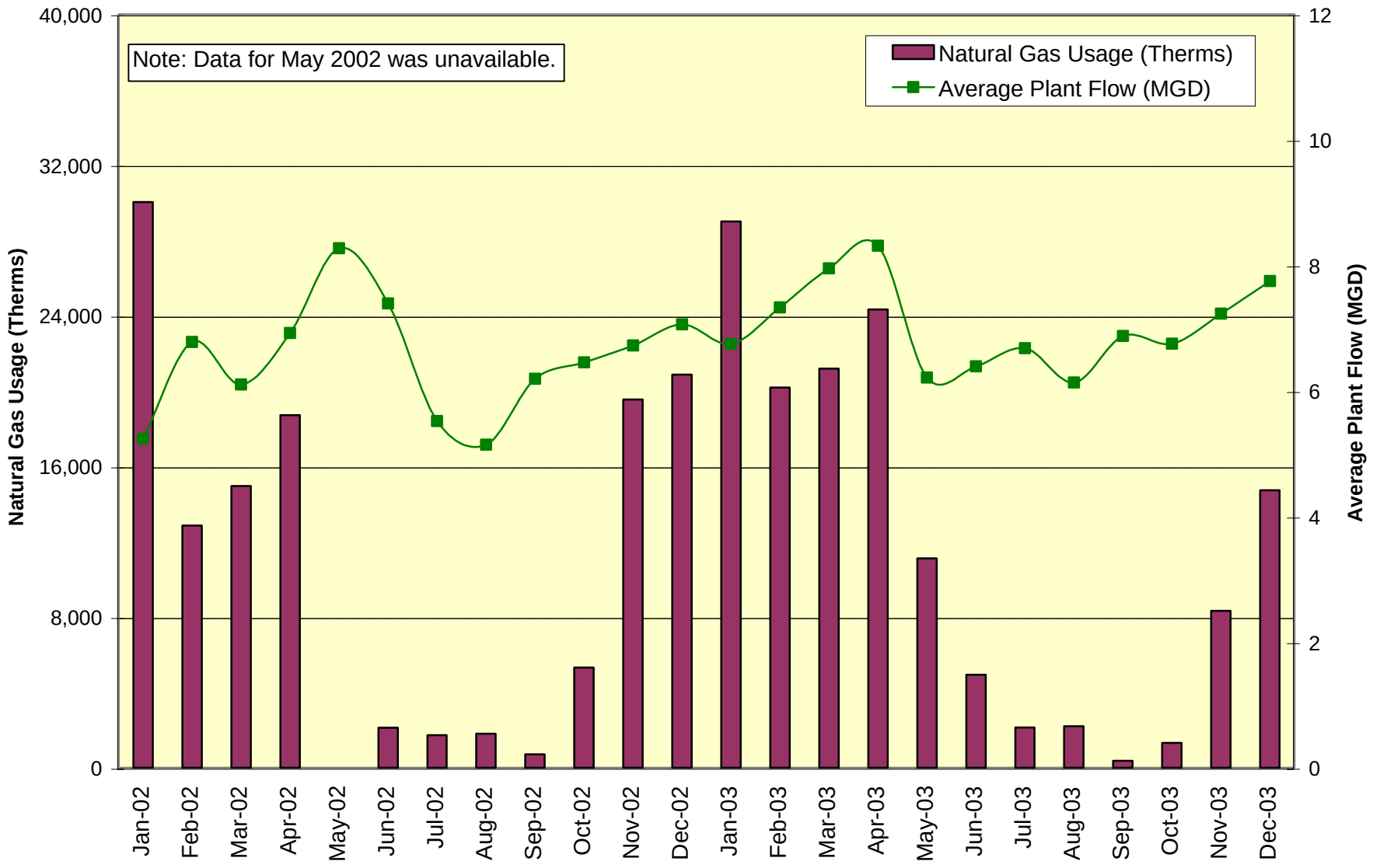

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FIGURE 2-9
NATURAL GAS USAGE vs AVERAGE PLANT FLOW

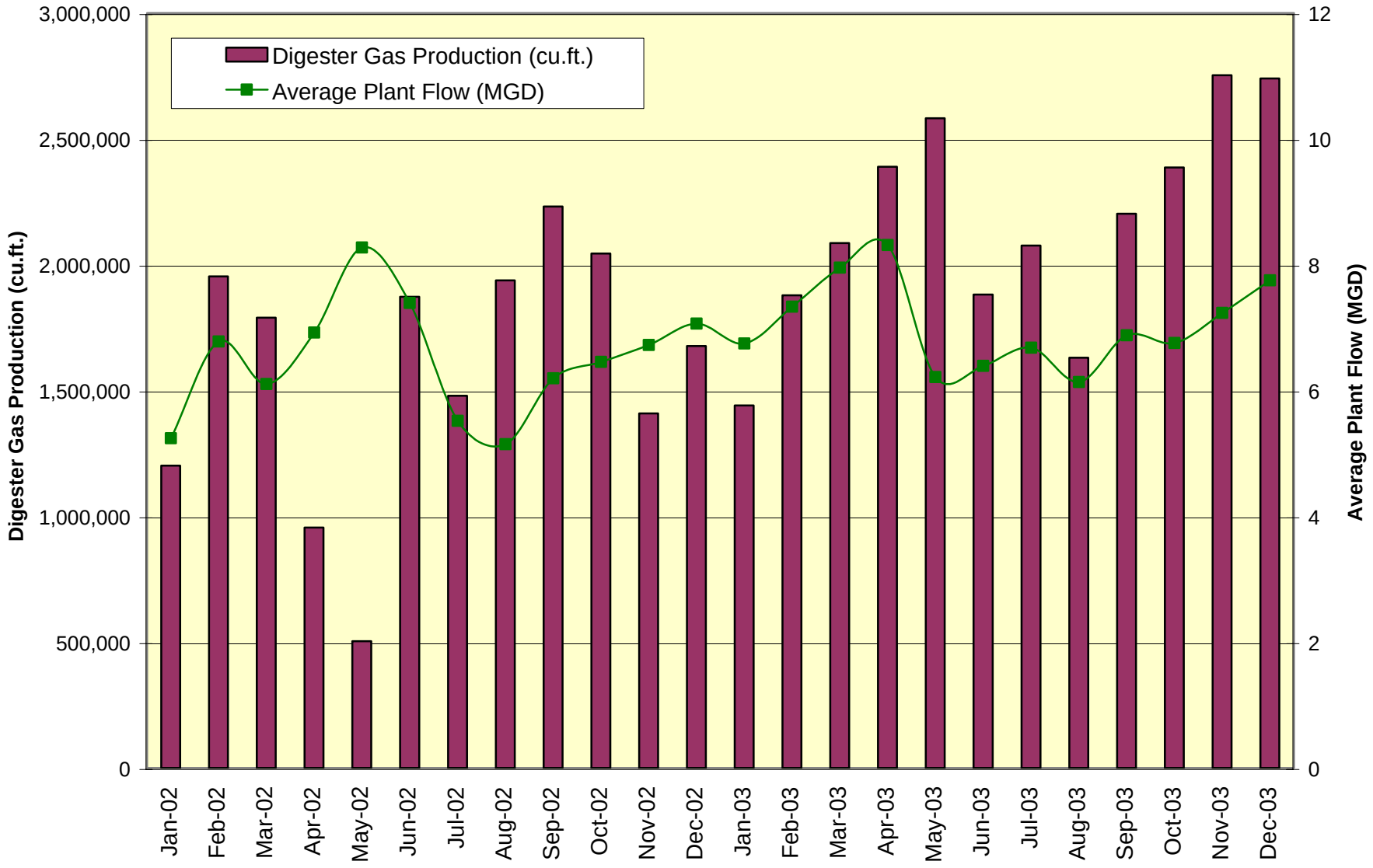

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FIGURE 2-10
MONTHLY DIGESTER GAS PRODUCTION vs AVERAGE PLANT FLOW

TABLE 2-3 summarizes the performance of the solids handling processes, based on historical data.

Table 2-3: Summary of IAWWTF Solids Handling Processes

Parameter	**Average**	
	2002	**2003**
Waste Activated Sludge to Thickeners (MGD)	0.18	0.18
Septage to Primary Digester (gpd)	15,170	14,373
Sludge to Primary Digester (gpd)	35,060	39,458
Pumped Digested Sludge (gpd)	36,886	38,832
Digester Gas Produced (cu. ft. per day)	52,347	71,362
Cake Solids (%)	22.4%	21.6%
Dry cake (tons/day)	6.3	5.7

Section 3

ELECTRIC SUBMETERING PROGRAM

3.1 DESCRIPTION OF SUBMETERING PROGRAM AND SUBMETER LOCATIONS

3.1.1 Description of Program

TABLE 3-1 summarizes the motors at the Ithaca Area Wastewater Treatment Facility (IAWWTF) that are 5 horsepower (hp) or greater. Submetering was conducted on larger motors to capture data for energy-intensive processes.

Continuous submetering was conducted through installation of submeters with continuous recording electronic data loggers (CREDLs). Continuous submetering was used to capture diurnal variations in electric energy demand for major pieces of equipment, as well as to provide a representative sample of electric energy usage and demand as equipment cycles on and off.

Instantaneous submetering was also conducted on representative pieces of equipment, usually those that operated at a constant speed according to a set schedule and driven by motors rated at 5 hp or greater. The instantaneous readings and estimated operating hours were then used to estimate total electric energy usage for the particular piece of equipment.

3.1.2 Submeter Locations

Based on a plant walk-through and existing plant information, continuously recording submeters were installed at a total of nine locations:

- Two meters on the influent pumps, one meter for each of the two influent pumps with variable frequency drives (VFDs) that are in operation during normal and most high flow conditions.
- Two meters on the aeration blowers, one meter for each blower in operation.
- Two meters on the return activated sludge (RAS) pumps, one meter for each pump with VFD in operation.
- One meter on the solids handling building motor control center (MCC) for the belt filter press.
- Two meters on the digester gas fueled co-generators, one meter for each co-generator.

The submeters were installed from September 17, 2004 to October 31, 2004.

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Municipal Wastewater Treatment Plant Energy Evaluation

Ithaca Area Wastewater Treatment Facility

Table 3-1 List of Motors over 5 hp

Process	Component	Quantity	Rated hp	No. of Units Typically in Operation
Wastewater Pumping	Influent Pumps	3	100	2
	Influent Pump #1		100	1
	Influent Pump #2		100	1
	Influent Pumps	2	150	0
	Controlled Diversion Pumps	2	60	0
Preliminary Treatment	Mechanical Bar Screens	2	5	2
Primary Treatment	Primary Sludge Pumps #1 and #2	2	7.5	1
	Primary Sludge Pump #3	1	10	1
Secondary Treatment	Air Blowers 1 - 4	4	125	2
	Air Blower #1		125	1
	Air Blower #2		125	1
	Return Sludge Pumps 1 - 5	5	20	2
	RAS Pump #2		20	1
	RAS Pump #5		20	1
Heating, Ventilation, and Air Conditioning	H.V. #1	1	7.5	1
	H.V. #3	1	20	1
	H.V. #4	1	7.5	1
	H.V. #5	1	15	1
	H.V. #8	1	7.5	1
	Exhaust Fan #1	1	5	1
	Exhaust Fan #3	1	5	1
	Exhaust Fan #5	1	5	1
	Exhaust Fan #10	1	5	1
	Exhaust Fan #11	1	5	1
	Exhaust Fan #12	1	5	1
	Exhaust Fan #19	1	7.5	1
	Exhaust Fan #26	1	15	1
	H.R. Circulation Pump #5	1	5	1
	H.R. Circulation Pump #9	1	10	1
	H.R. Circulation Pump #11	1	5	1
	H.R. Circulation Pump #13	1	7.5	1
	H.R. Circulation Pump #16	1	7.5	1
	Main H.W. Circulation Pump #1and #2	2	15	1
	H.W. Circulation Pump #20	1	5	1
	Boiler #1 and #2	2	7.5	1
	Main H.W. Circulation Pump #3	1	7.5	1
Digester Gas Co-Generators	H.W. Circulation Pump #3, #4,and #5	3	5	2
Solids Handling	Heat Exchange Pumps #1 and #2	2	20	1
	Septage Pumps #1 and #2	2	20	1
	Digester Sludge Pumps #1, #2, and #3	3	7.5	1
	Thickened Sludge Pumps	3	7.5	2
	Thickener Makeup Pumps	2	20	1
	Mixing Compresser #1 and #2	2	40	1
	Septage Mixers #1 and #2	2	10	1
	Belt Filter Press	1	7.5	1
	Primary Scum Box Mixer	1	7.5	1
	Wash Water Booster Pump	1	7.5	1
	Circulation Pump #1 and #2	2	20	1
Plant Water	Effluent Water Pumps #1and #2	2	25	1
Miscellaneous	Sump Pumps	8	5	8

	Monitored with continuous submeters
	Could not access during site visit
	Not in Operation
	Out of Service
	Could not locate motor during walk-through

3.2 SUMMARY OF SITE AUDIT

A one-day on-site survey was conducted to:

- Document existing equipment, operations and lighting.
- Finalize the list of opportunities for energy improvements.
- Finalize the submetering approach.

The submetering locations listed in Section 3.1.2 were finalized as a result of the site audit. In addition, the site survey assessed the existing equipment at the plant with 5-hp or greater motors. As shown by the data in TABLE 3-1, the motors that may use the most electric energy are those on the influent wastewater pumps and the aeration system blowers.

3.3 SUMMARY OF CONTINUOUS SUBMETERING

The following sections summarize the results from continuous submetering activities. Continuous readings for total electric energy demand data for the entire plant were not available.

3.3.1 Digester-Gas Fueled Co-generators

There are two 110-kW co-generators that are primarily run using digester gas. Continuous submeters were installed on both digester gas fueled co-generators. The patterns of electric energy production during the submetering period are shown on FIGURE 3-1. The data illustrate that co-generator 1 was continuously operational for the duration of the submetering period except between October 14, 2004 and October 19, 2004 and co-generator 2 was operational only from the start of the submetering program until October 19, 2004.

When in operation (electric energy production > 0 kW), the average electric energy production values for co-generators 1 and 2 were 101.2 kW (135.5 hp) and 99.3 kW (133.1 hp), respectively. Typically only one co-generator is in operation. However, if sufficient methane is available, a second co-generator is brought online as was the case during the submetering period. IAWWTF staff also noted that typically one co-generator operates continuously, while the second co-generator typically operates for approximately 6 months per year 8 hours per day, although this may vary depending on methane production.

The estimated electric energy produced by the co-generators during the submetering period was 95,335 kWh and 70,015 kWh, respectively. The cost savings was estimated based on the 2003 average cost of

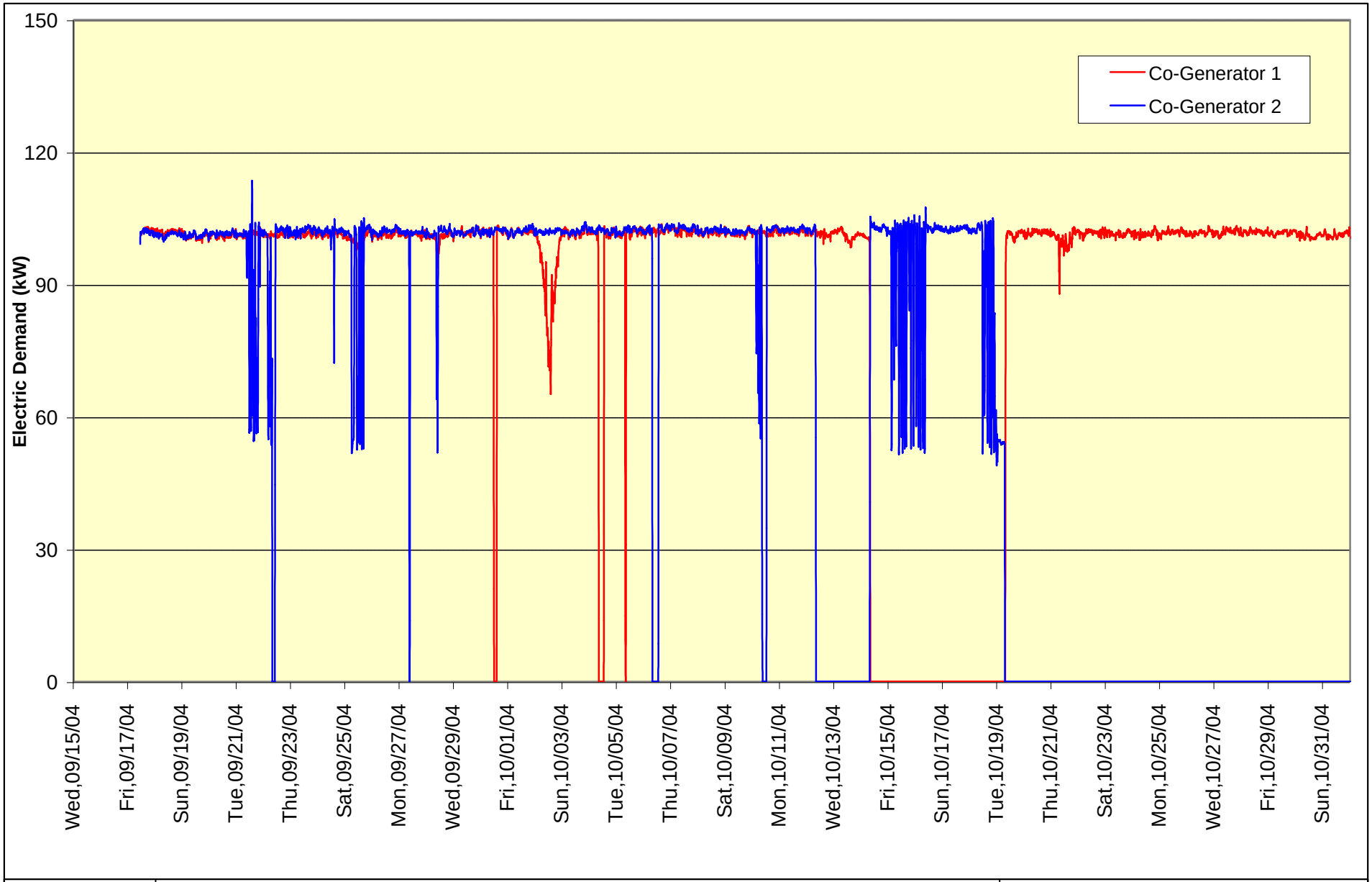

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FIGURE 3-1
SUBMETERING - DIGESTER-GAS FUELED CO-GENERATORS 1 AND 2

$0.09 per kWh. If the numbers obtained during submetering are extrapolated to an entire year, it is estimated that approximately 1,354,310 kWh would be the combined electric energy produced by the two co-generators per year. However, based on the information provided by the IAWWTF staff, the second co-generator only operates approximately 6 months per year, which is not accounted for in the submetering period data. Therefore, a revised electric energy production was estimated at 1,022,000 kWh for the two co-generators (one co-generator operating continuously and one co-generator operating 6 months for 8 hours per day) with an estimated electric energy cost savings of $94,539. This cost is approximately what the IAWWTF saves each year by using digester gas for on-site generation to supplement the electricity purchased from NYSEG. The revised estimated electric energy production by the co-generators was added to the billed electric energy usage to estimate the total electric energy usage at the plant.

3.3.2 Influent Pumps

There are three 100-hp and two 150-hp influent pumps in the main pump building, three of which have VFDs. The pumps are operated to maintain a set wet well level. During average flow conditions, only one pump with VFD is operated. During high flow conditions, two pumps with VFDs are operated. Flow conditions rarely occur where more than three pumps are required to be in operation at the same time. Submeters were installed on the two influent pumps with VFDs that are in operation during normal and most high flow conditions. FIGURE 3-2 presents the electric energy demand for influent pumps 1 and 2 during the continuous submetering period.

FIGURE 3-2 shows that influent pump 2 was operational during the entire submetering period. A typical diurnal pattern is observed in the electric energy demand at this pump. Influent pump 1 did not operate continuously during the submetering period as it is typically in operation only during high flow conditions.

When in operation (electric energy demand > 0 kW), influent pumps 1 and 2 had an average power draw of 67.2 kW (90 hp) and 56.4 kW (75.6 hp), respectively, during the submetering period. The estimated electric energy usage for influent pumps 1 and 2 during the submetering period was 15,731 kWh and 60,364 kWh, respectively. The cost per kWh was estimated based on the 2003 average cost of $0.09 per kWh.

If the numbers obtained during submetering are extrapolated to an entire year, it is estimated that approximately 623,270 kWh would be the combined electric energy usage of the two influent pumps per year, which would account for 18.2% of the total annual electric energy usage (billed and on-site generation) with an annual electric energy cost of $57,655.

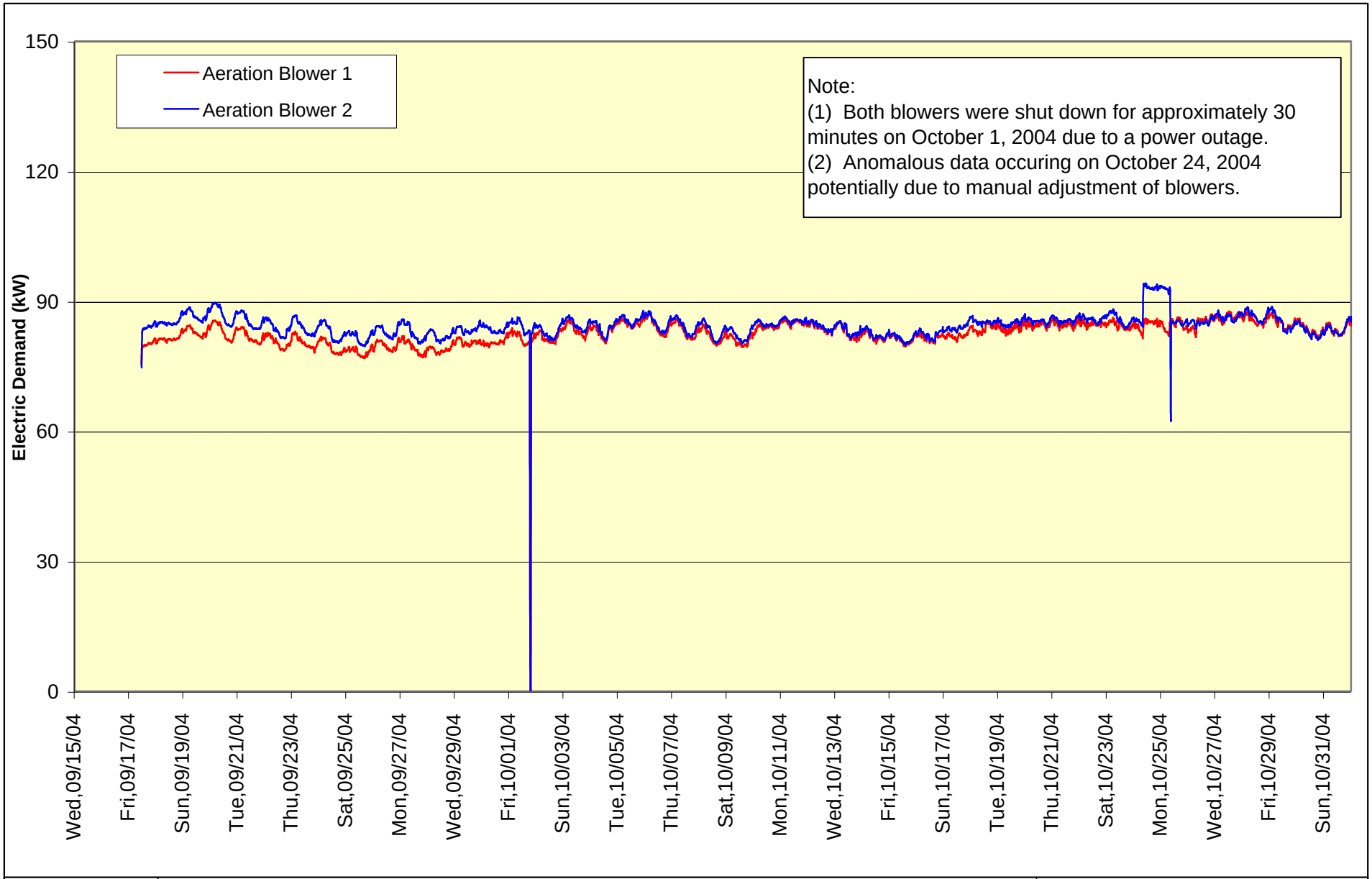

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FIGURE 3-3
SUBMETERING - AERATION SYSTEM BLOWERS 1 AND 2

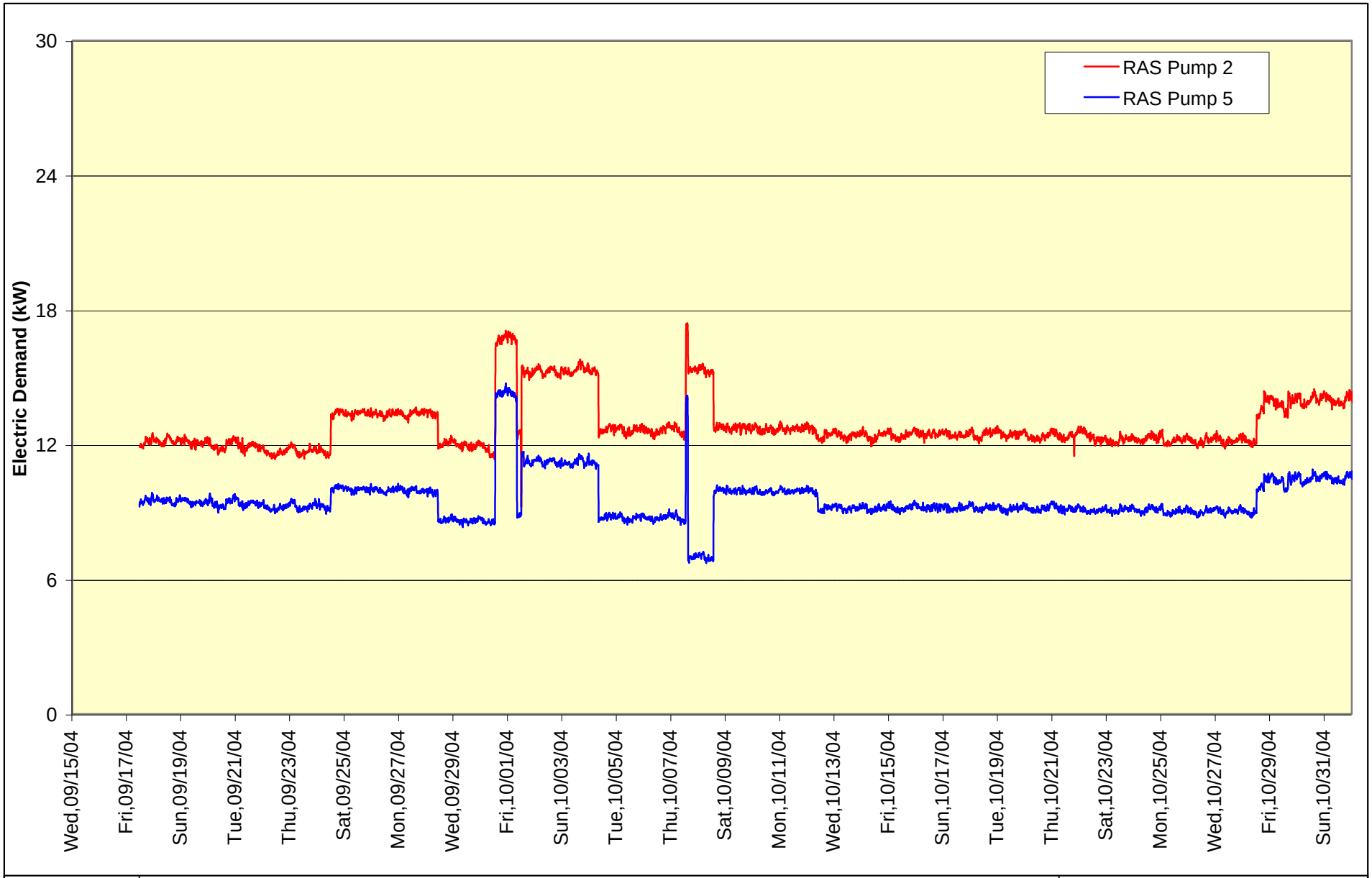

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FIGURE 3-4
SUBMETERING -RAS PUMPS 2 AND 5

which would account for 5.7% of the total annual electric energy usage with an annual electric energy cost of $18,161.

3.3.5 Solids Handling Building Belt Filter Press

There is one 7.5-hp belt filter press used for dewatering. Digested sludge is pumped to the belt filter press. A submeter was installed on the solids handling building MCC for the belt filter press. FIGURE 3-5 shows the operation of the belt filter press during the continuous submetering period. From FIGURE 3-5, it can be seen that the belt filter press operates during week days (Monday through Friday) for approximately 8 hours a day (7 AM to 3 PM).

When in operation (electric energy demand > 1 kW), the belt filter press had an average electric energy demand of 7.7 kW (10.3 hp). The estimated electric energy usage for the belt press during the submetering period was 1,340 kWh.

If the numbers obtained during submetering are extrapolated to an entire year, it is estimated that approximately 15,999 kWh would be the electric energy usage of the belt filter press per year, which would account for 0.5% of the total annual electric energy usage with an annual electric energy cost of $1,480.

3.4 SUMMARY OF INSTANTANEOUS SUBMETERING

Instantaneous power draw measurements were obtained from motors greater than 5 hp at the plant for equipment that is either in continuous use or operated on a set schedule. The data were collected to verify electric energy demand at the facility, as well as to monitor changes in electric energy demand as the equipment is cycled on and off.

The instantaneous measurements were obtained using hand-held meters. TABLE 3-2 summarizes the instantaneous power draw and estimated operating hours for each piece of equipment over 5 hp.

Based on the instantaneous and continuous submetered power draw measurements, and the estimated equipment operating hours provided by plant staff, TABLE 3-3 shows the estimated annual electric energy usage and associated costs. The continuous submetering data were used to estimate electric energy usage for the aeration system blowers, influent wastewater pumps, RAS pumps, and solids handling building MCC.

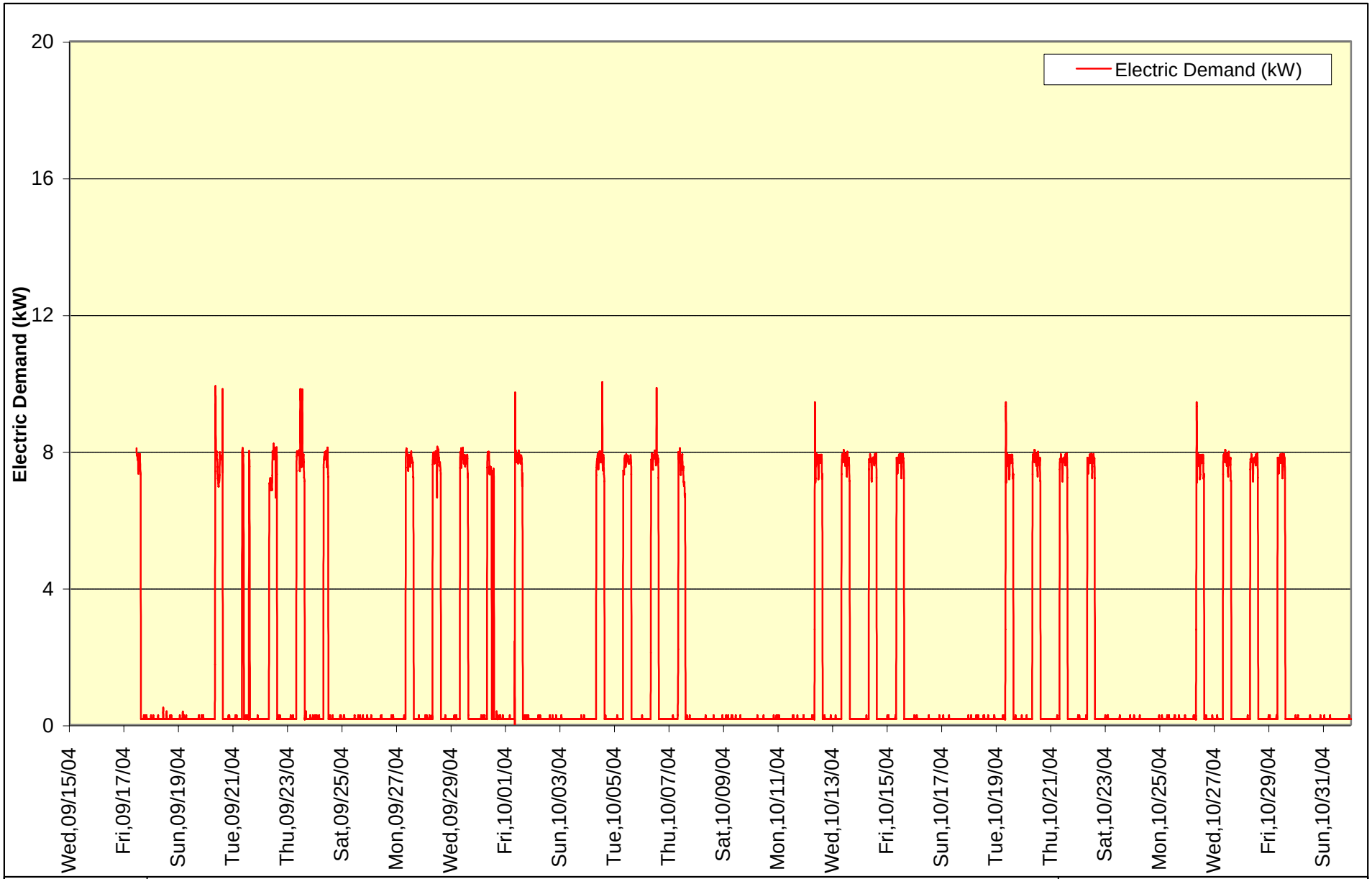

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FIGURE 3-5
SUBMETERING -BELT FILTER PRESS

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Ithaca Area Wastewater Treatment Facility

Table 3-2 Instantaneous Power Draw Measurements and Estimates of Hours in Operation

Process	Component	Quantity	Rated hp	No. of Units Typically in Operation	Hours Per Day	Days per Week	Weeks per Year	Estimated Annual Operating Hours	Measured Power Draw (kw)	Notes
Wastewater Pumping	Influent Pumps	3	100	2						
	Influent Pump #1			1				1,919	67.15	Influent pump #1 operated only during wet weather. Operating hours projected to one year from the operating hours during the submetering period.
	Influent Pump #2			1	24	7	52	8,760	56.44	
	Influent Pumps	2	150	0						
	Controlled Diversion Pumps	2	60	0						
Preliminary Treatment	Mechanical Bar Screens	2	5	2	6	7	52	4,380	2.20	
Primary Treatment	Primary Sludge Pumps #1 and #2	2	7.5	1	24	7	52	8,760	3.50	Reading taken from pump #1; pump #2 was not operational
	Primary Sludge Pump #3	1	10	1	24	7	52	8,760	5.60	
Secondary Treatment	Air Blowers 1 - 4	4	125	2						
	Air Blower #1			1	24	7	52	8,760	82.64	
	Air Blower #2			1	24	7	52	8,760	84.43	
	Return Sludge Pumps 1 - 5	5	20	2						
	RAS Pump #2			1	24	7	52	8,760	12.86	
	RAS Pump #5			1	24	7	52	8,760	9.55	
Heating, Ventilation, and Air Conditioning	H.V. #1	1	7.5	1	24	7	52	8,760		
	H.V. #3	1	20	1	24	7	52	8,760	13.30	
	H.V. #4	1	7.5	1	24	7	52	8,760	4.10	
	H.V. #5	1	15	1	24	7	52	8,760	7.10	
	H.V. #8	1	7.5	1	24	7	52	8,760		
	Exhaust Fan #1	1	5	1	6	7	52	2,190		On/Off 24
	Exhaust Fan #3	1	5	1	6	7	52	2,190	4.50	On/Off 24
	Exhaust Fan #5	1	5	1	6	7	52	2,190	4.60	On/Off 24
	Exhaust Fan #10	1	5	1	6	7	52	2,190		On/Off 24
	Exhaust Fan #11	1	5	1	6	7	52			On/Off 24
	Exhaust Fan #12	1	5	1	6	7	52	2,190	3.30	On/Off 24
	Exhaust Fan #19	1	7.5	1	6	7	52			On/Off 24
	Exhaust Fan #26	1	15	1	6	7	52	2,190	11.10	On/Off 24
	H.R. Circulation Pump #5	1	5	1	24	7	26	4,380		Half Year
	H.R. Circulation Pump #9	1	10	1	24	7	26	4,380	7.40	Half Year
	H.R. Circulation Pump #11	1	5	1	24	7	26			Half Year
	H.R. Circulation Pump #13	1	7.5	1	24	7	26			Half Year
	H.R. Circulation Pump #16	1	7.5	1	24	7	26			Half Year
	Main H.W. Circulation Pump #1 and # 2	2	15	1	24	7	52	8,760	12.50	Reading taken from pump #2 ; pump #1 was not operational
	H.W. Circulation Pump #20	1	5	1	24	7	52	8,760	3.60	
	Boiler #1 and #2	2	7.5	1	24	7	26	4,380	6.30	Reading taken from #1 boiler; #2 boiler not operational; #2 out of service. Operated Half Yearly
	Main H.W. Circulation Pump #3	1	7.5	1	24	7	16	2,688	6.50	Only operational during summer months
Digester Gas Co-Generators	H.W. Circulation Pump # 3, #4, and #5	3	5	2	24	7	52	17,520	3.00	Reading taken from #3 pump; pump #4, and #5 not operational
Solids Handling	Heat Exchange Pumps #1 and #2	2	20	1	24	7	52	8,760	8.00	Reading taken from #2 pump; pump #1 was not operational
	Septage Pumps #1 and #2	2	20	1	1	5	52	261	16.40	1 hour per day for 5 days per week
	Digester Sludge Pumps #1, #2, and #3	3	7.5	1	8	7	52	2,920	2.20	Reading taken from #1 pump; pump #2 and #3 not operational.
	Thickened Sludge Pumps	3	7.5	2	6	7	52	4,380	4.70	
	Thickener Makeup Pumps	2	20	1	1		26	26	14.70	1 hour every two weeks
	Mixing Compresser #1 and #2	2	40	1	8	7	52	2,920	26.70	Reading taken from compressor #1; compressor #2 was not operational.
	Septage Mixers #1 and #2	2	10	1	1	5	52	261	6.50	Reading taken from mixer #1; mixer #2 was not operational. #1- 1 hour per day for 5 days per week.
	Belt Filter Press	1	7.5	1	8	5	52	2,086	7.67	
	Primary Scum Box Mixer	1	7.5	1	1		26	26	6.10	1 hour every two weeks
	Wash Water Booster Pump	1	7.5	1	6	7	52	2,190	4.80	
	Circulation Pump #1and #2	2	20	1	24	7	52	8,760	12.80	Reading taken from pump #1; pump #2 was not operational
Plant Water	Effluent Water Pumps #1 and #2	2	25	1	24	7	52	8,760	12.50	24/7 all year long; one in operation; the other not in operation
Miscellaneous	Sump Pumps	8	5	8	1	7	52	2,920	3.80	Reading taken from sump pump #8; reading also taken from #7 = 4.1 kW (On/Off 24)

Estimated Cost per kWh for 2003 $ 0.093

- Monitored with continuous submeters
- Could not access during site visit
- Not in Operation
- Out of Service
- Could not locate motor during walk-through
- Operational only during summer months - 16 weeks
- Reading taken from Sump Pump # 8

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Ithaca Area Wastewater Treatment Facility

Table 3-3 Estimates of Electric Usage and Costs

Process	Component	Quantity	Rated hp	No. of Units Typically in Operation	Estimated Annual Operating Hours	Measured Power Draw (kw)	Estimated Annual Usage (kWh)	Cost ($)	Notes
Wastewater Pumping	Influent Pumps	3	100	2					
	Influent Pump #1			1	1,919	67.15	128,845	$11,919	Influent pump #1 operated only during wet weather. Operating hours projected to one year from the operating hours during the submetering period.
	Influent Pump #2			1	8,760	56.44	494,426	$45,736	
	Influent Pumps	2	150	0					
	Controlled Diversion Pumps	2	60	0					
Preliminary Treatment	Mechanical Bar Screens	2	5	2	4,380	2.20	9,636	$891	
Primary Treatment	Primary Sludge Pumps #1 and #2	2	7.5	1	8,760	3.50	30,660	$2,836	Reading taken from pump #1; pump #2 was not operational
	Primary Sludge Pump #3	1	10	1	8,760	5.60	49,056	$4,538	
Secondary Treatment	Air Blowers 1 - 4	4	125	2					
	Air Blower #1			1	8,760	82.64	723,963	$66,969	
	Air Blower #2			1	8,760	84.43	739,582	$68,414	
	Return Sludge Pumps 1 - 5	5	20	2					
	RAS Pump #2			1	8,760	12.86	112,685	$10,424	
	RAS Pump #5			1	8,760	9.55	83,639	$7,737	
Heating, Ventilation, and Air Conditioning	H.V. #1	1	7.5	1	8,760				
	H.V. #3	1	20	1	8,760	13.30	116,508	$10,777	
	H.V. #4	1	7.5	1	8,760	4.10	35,916	$3,322	
	H.V. #5	1	15	1	8,760	7.10	62,196	$5,753	
	H.V. #8	1	7.5	1	8,760				
	Exhaust Fan #1	1	5	1	2,190			$0	On/Off 24
	Exhaust Fan #3	1	5	1	2,190	4.50	9,855	$912	On/Off 24
	Exhaust Fan #5	1	5	1	2,190	4.60	10,074	$932	On/Off 24
	Exhaust Fan #10	1	5	1	2,190			$0	On/Off 24
	Exhaust Fan #11	1	5	1					On/Off 24
	Exhaust Fan #12	1	5	1	2,190	3.30	7,227	$669	On/Off 24
	Exhaust Fan #19	1	7.5	1					On/Off 24
	Exhaust Fan #26	1	15	1	2,190	11.10	24,309	$2,249	On/Off 24
	H.R. Circulation Pump #5	1	5	1	4,380			$0	Half Year
	H.R. Circulation Pump #9	1	10	1	4,380	7.40	32,410	$2,998	Half Year
	H.R. Circulation Pump #11	1	5	1					Half Year
	H.R. Circulation Pump #13	1	7.5	1					Half Year
	H.R. Circulation Pump #16	1	7.5	1					Half Year
	Main H.W. Circulation Pump #1and #2	2	15	1	8,760	12.50	109,500	$10,129	Reading taken from pump #2 ; pump #1 was not operational
	H.W. Circulation Pump #20	1	5	1	8,760	3.60	31,536	$2,917	
	Boiler #1and #2	2	7.5	1	4,380	6.30	27,592	$2,552	Reading taken from #1 boiler; #2 boiler not operational; #2 out of service. Operated Half Yearly
	Main H.W. Circulation Pump #3	1	7.5	1	2,688	6.50	17,472	$1,616	Only operational during summer months
Digester Gas Co-Generators	H.W. Circulation Pump #3, #4, and #5	3	5	2	17,520	3.00	52,560	$4,862	Reading taken from #3 pump; pump #4, and #5 not operational
Solids Handling	Heat Exchange Pumps #1and #2	2	20	1	8,760	8.00	70,080	$6,483	Reading taken from #2 pump; pump #1 was not operational
	Septage Pumps #1and #2	2	20	1	261	16.40	4,276	$396	1 hour per day for 5 days per week
	Digester Sludge Pumps #1, #2, #3	3	7.5	1	2,920	2.20	6,424	$594	Reading taken from #1 pump; pump #2, and #3 not operational.
	Thickened Sludge Pump	3	7.5	2	4,380	4.70	20,586	$1,904	
	Thickener Makeup Pumps	2	20	1	26	14.70	383	$35	1 hour every two weeks
	Mixing Compresser #1and #2	2	40	1	2,920	26.70	77,964	$7,212	Reading taken from compressor #1; compressor #2 was not operational.
	Septage Mixers #1and #2	2	10	1	261	6.50	1,695	$157	Reading taken from mixer #1; mixer #2 was not operational. #1- 1 hour per day for 5 days per week.
	Belt Filter Press	1	7.5	1	2,086	7.67	15,999	$1,480	
	Primary Scum Box Mixer	1	7.5	1	26	6.10	159	$15	1 hour every two weeks
	Wash Water Booster Pump	1	7.5	1	2,190	4.80	10,512	$972	
	Circulation Pump #1and #2	2	20	1	8,760	12.80	112,128	$10,372	Reading taken from pump #1; pump #2 was not operational
Plant Water	Effluent Water Pumps #1and #2	2	25	1	8,760	12.50	109,500	$10,129	24/7 all year long; one in operation; the other not in operation
Miscellaneous	Sump Pumps	8	5	8	2,920	3.80	11,096	$1,026	Reading taken from sump pump #8; reading also taken from #7 = 4.1 kW (On/Off 24)

Estimated Cost per kWh for 2003	$	0.093	Total	3,350,452	$309,930

	Monitored with continuous submeters
	Could not access during site visit
	Not in Operation
	Out of Service
	Could not locate motor during walk-through
	Reading taken from Sump Pump #8

3.5 SUMMARY OF ENTIRE SUBMETERING PROGRAM

TABLE 3-4 shows the electric energy usage and costs and the corresponding percentages of total electric energy usage for the metered major equipment and processes at the IAWWTF.

Table 3-4: Summary of Major Equipment Total Estimated Electric Energy Usage and Costs at the IAWWTF

Equipment	Electric Energy Usage (kWh)[1]	Cost	Percentage of Total Usage
Influent Pumps	623,271	$57,655	18.2%
Mechanical Bar Screens	9,636	$891	0.3%
Primary Sludge Pumps	79,716	$7,374	2.3%
Aeration Blowers	1,463,545	$135,383	42.7%
Return Activated Sludge Pumps	196,325	$18,161	5.7%
Heat Exchange Pumps	70,080	$6,483	2.1%
Septage Pumps	4,276	$396	0.1%
Effluent Water Pumps 1, 2	109,500	$10,129	3.2%
Digester Sludge Pumps	6,424	$594	0.2%
Thickened Sludge Pumps	20,586	$1,904	0.6%
Thickener Make-up Pumps	383	$35	0.01%
Mixing Compressors	77,964	$7,212	2.3%
Septage Mixers	1,695	$157	0.05%
Belt Filter Press	15,999	$1,480	0.5%
Primary Scum Box Mixer	159	$15	0.01%
Wash Water Booster Pump	10,512	$972	0.3%
Circulation Pumps 1,2	112,128	$10,372	3.3%
Heating/Ventilation	484,597	$44,827	14.1%
Misc. – Sump Pumps	11,096	$1,026	0.3%
Circulation Pumps 3, 4, 5	52,560	$4,862	1.5%
Total Submetered Usage	***3,350,452***	***$309,928***	***NA[2]***
Estimated Co-Generator Electric Energy Production	1,022,000	$94,539	NA[2]
2003 Total Billed Usage (kWh)	2,404,800	$220,876	NA[2]
Total Estimated Annual Usage	***3,426,800***	***$315,415***	***100%***
Other[3]	***76,348***	***$5,485***	***2.23%***

Notes:
1. Power usage based on both instantaneous and continuous (for those pieces of equipment continuously metered) measurements.
2. NA – Not applicable.
3. "Other" electric energy usage represents electric energy usage by equipment with motors less than 5 hp. It is estimated as:
Other = Total Estimated Annual Usage – Total Submetered Usage.
The Total Estimated Annual Usage is estimated as:
Total Estimated Annual Usage = Estimated Co-Generator Electric Energy Production + 2003 Total Billed Usage

From the table, it is apparent that the largest "identified" users of electric energy at the plant are the aeration system blowers, influent pumps, heating and ventilation, RAS pumps, and effluent water pumps. The total energy usage for the submetered equipment was estimated as a sum of energy usages for each

piece of equipment that was submetered. The co-generators produce a portion of the electric energy used by the plant equipment, which is not accounted for in the billed electric energy usage and costs. Therefore, the estimated co-generator electric energy production was added to the 2003 total billed electric energy usage and then compared to the total submetered electric energy usage. The total submetered annual usage from TABLE 3-3 was then subtracted from the net annual electric energy usage to estimate the "Other" usage. Approximately 2.23% of the total usage is accounted for as "Other" which would involve other plant equipment with electric motors less than 5 hp that were not included as part of this submetering program.

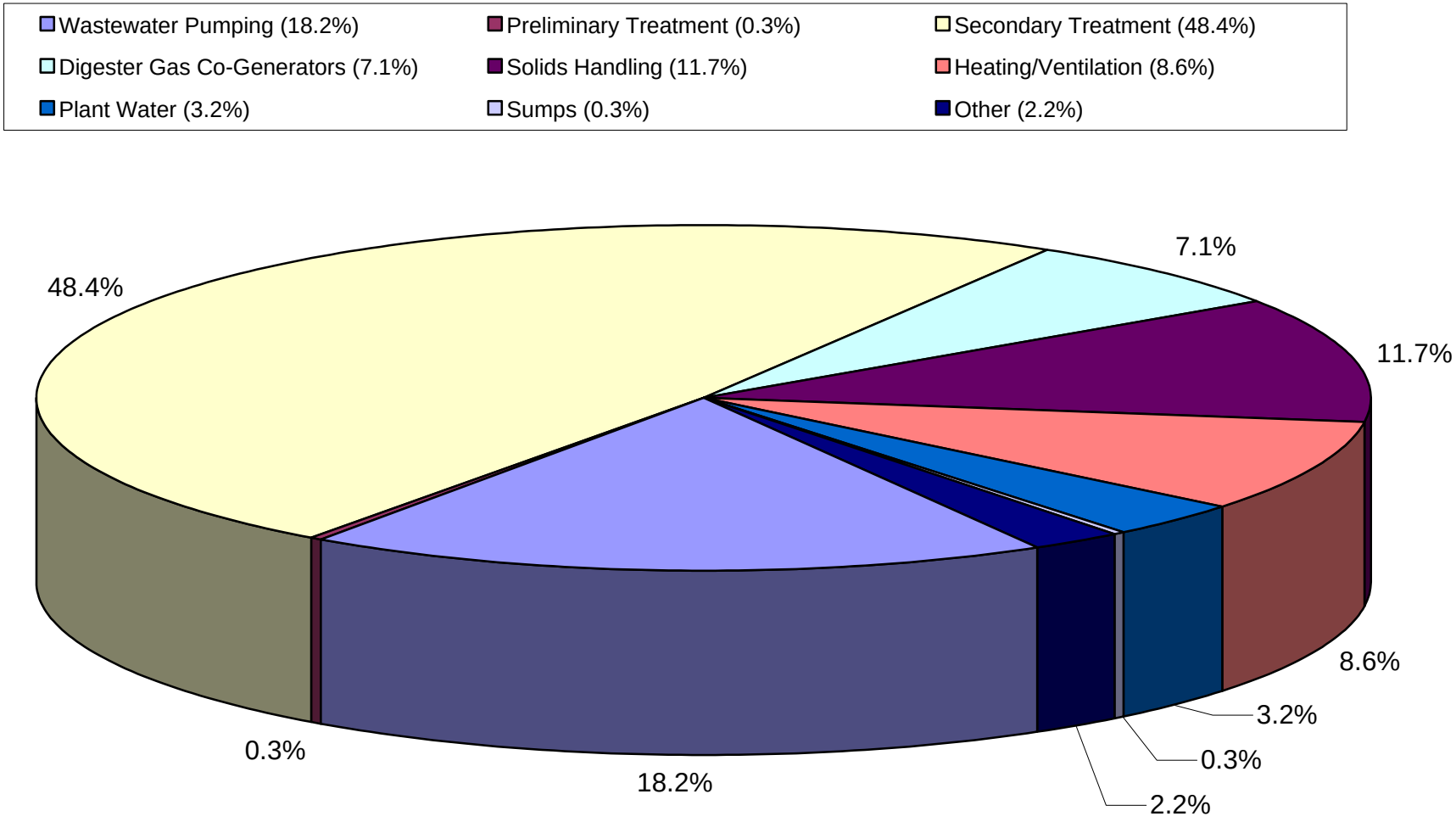
FIGURE 3-6 shows the distribution of estimated electric energy usage among the major processes at the plant. Equipment was grouped into processes as follows:

- Wastewater Pumping - Influent pumps only.
- Preliminary Treatment - Mechanical bar screens.
- Secondary Treatment - Aeration blowers and return sludge pumps.
- Digester Gas Co-generator - Hot water circulation pumps.
- Solids Handling - Heat exchange pumps, septage pumps, primary sludge pumps, digester sludge pumps, thickened sludge pumps, thickener make-up pumps, mixing compressors, septage mixers, belt press, primary scum box mixer, wash water booster pump, and circulation pumps.
- Heating/Ventilation - Boilers, hot water and cold water circulation pumps, chiller fans, and exhaust fans.
- Plant Water - Effluent water pumps.
- Sumps
- Other

The secondary treatment process consumes the most electric energy at the IAWWTF. It is estimated that approximately 0.88 kWh of electric energy is consumed per pound of BOD_5 removed in the secondary process.

The distribution of estimated electric energy usage in the solids handling process is shown on FIGURE 3-7. The solids handling equipment was categorized as follows:

- Pumping and mixing - Septage pumps and septage mixers, primary sludge pumps, and primary scum box mixer.
- Thickening - Thickened sludge pumps and thickener make-up pumps.



MALCOLM PIRNIE	**NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION** **ITHACA AREA WASTEWATER TREATMENT FACILITY**	**FIGURE 3-6** **DISTRIBUTION OF ELECTRIC ENERGY USAGE AMONG PROCESSES**

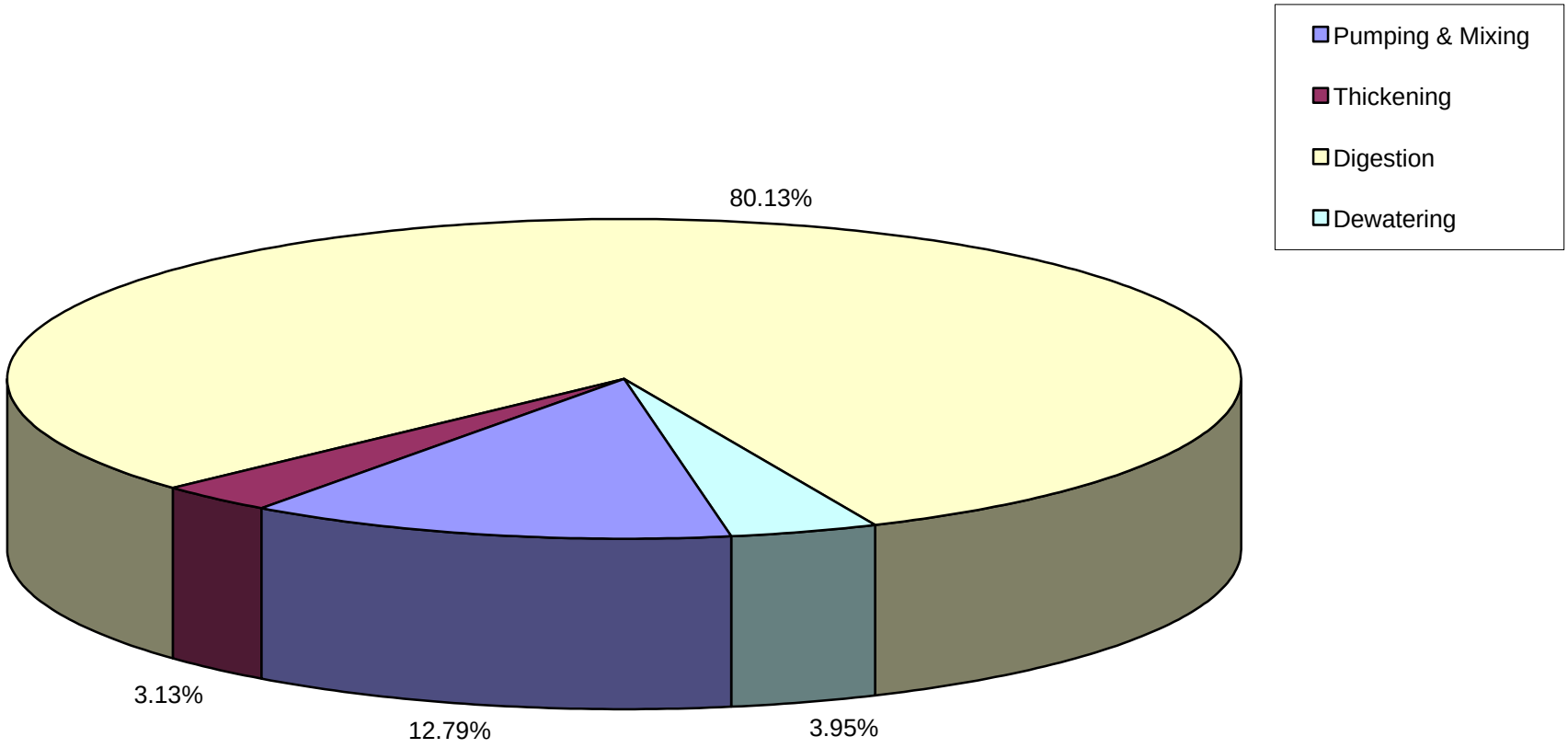


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FIGURE 3-7
DISTRIBUTION OF ELECTRIC ENERGY USAGE AMONG SOLIDS HANDLING PROCESSES

- Digestion - Digester sludge pumps, heat exchanger pumps, mixing compressors, and circulation pump.
- Dewatering - Belt filter press and wash water booster pump.

The digestion portion consumes the majority of the electric energy in the solids handling processes.

Section 4
PROCESS PERFORMANCE DURING SUBMETERING

In conjunction with the continuous submetering program, daily process data were collected for both the wet stream and solids handling processes. These data were compared with historical plant data to determine if plant operation during submetering and corresponding energy usage could be considered typical for the Ithaca Area Wastewater Treatment Facility (IAWWTF).

4.1 SUMMARY OF PROCESS PERFORMANCE PARAMETER MONITORING

For the duration of the submetering program, the following daily process performance data were collected:

- Average, minimum, and maximum daily flow.
- Influent, primary effluent and plant effluent biochemical oxygen demand (BOD_5) (two days per week).
- Influent, primary effluent and plant effluent total suspended solids (TSS) (two days per week).
- Return activated sludge (RAS) flow rate and suspended solids.
- Waste activated sludge (WAS) flow rate and suspended solids.
- Mixed liquor suspended solids (MLSS).
- Primary sludge quantities.
- Digester feed sludge quantities and total volatile solids percentage.
- Digested sludge quantities and total volatile solids percentage.
- Digester gas production.

FIGURE 4-1 shows the influent, primary effluent, and effluent BOD_5 concentrations during the course of the submetering program. BOD_5 is measured two days per week. BOD_5 concentrations do not appear to correlate with plant flow. FIGURE 4-2 shows the relationship between BOD_5 loading and plant flow. The data do not appear to show any correlation between flow and influent BOD_5 loading.

FIGURES 4-3 and 4-4 show the TSS concentrations and loadings for the influent, primary effluent, and plant effluent flows. TSS concentrations and loadings do not appear to have any correlation with flow during the submetering period.

The RAS flow rate was maintained at an average of 4.1 million gallons per day (MGD). Approximately 5.4% of the total activated sludge was wasted as WAS, at an average flow rate of 0.2 MGD.

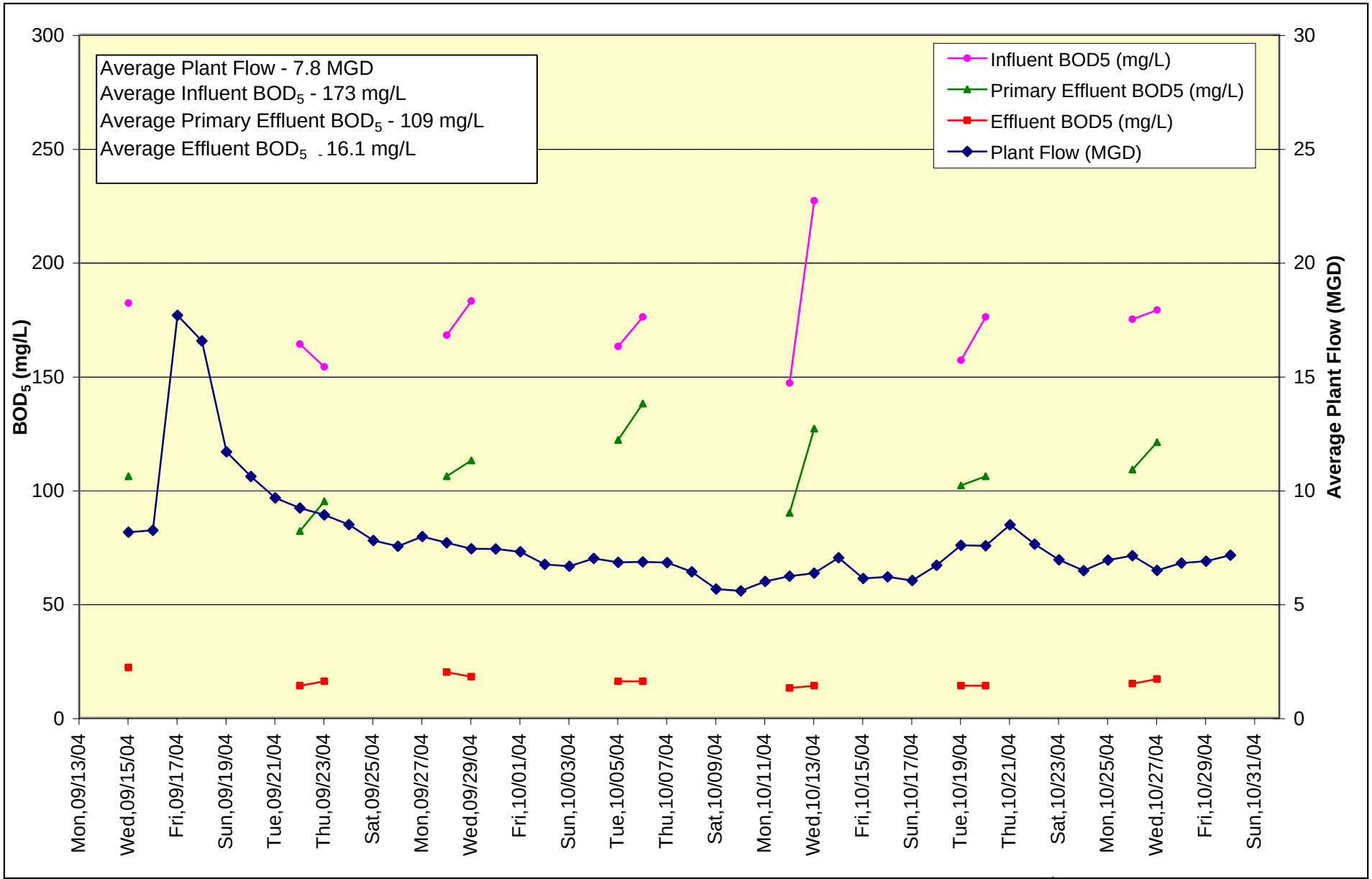

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FIGURE 4-1
SUBMETERING - BOD_5 vs PLANT FLOW

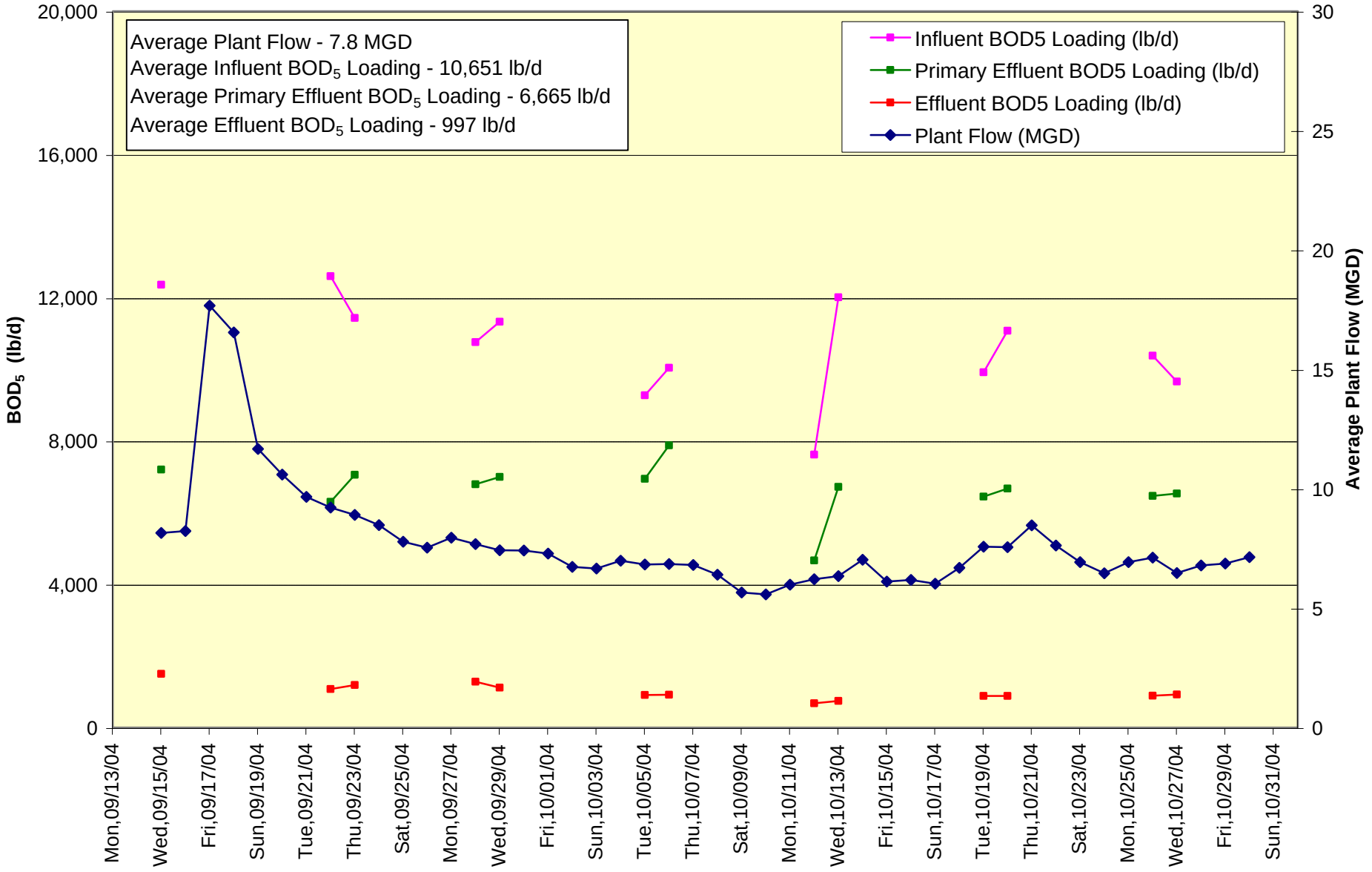

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FIGURE 4-2
SUBMETERING - BOD_5 LOADING vs PLANT FLOW

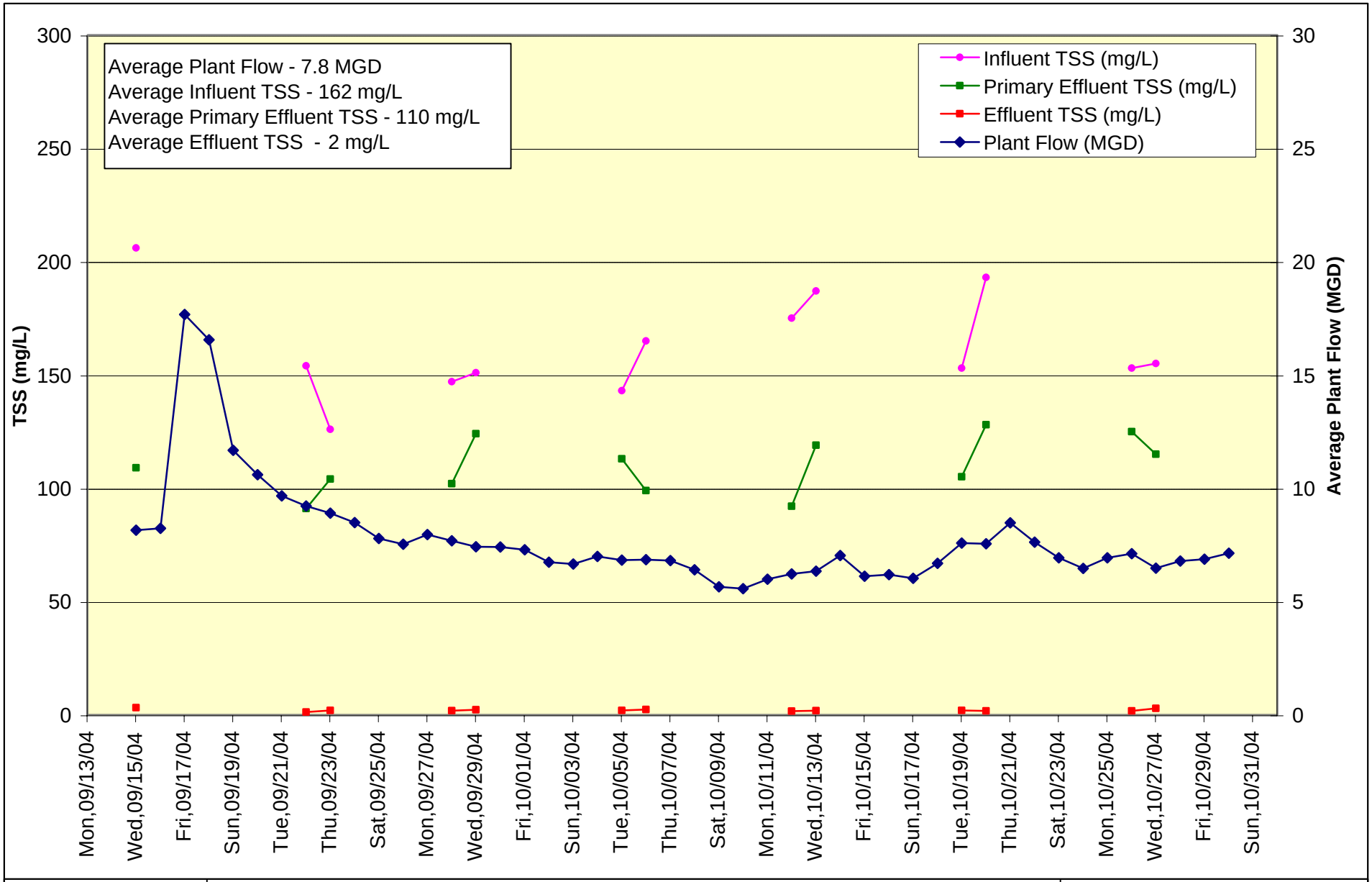

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FIGURE 4-3
SUBMETERING - TSS vs PLANT FLOW

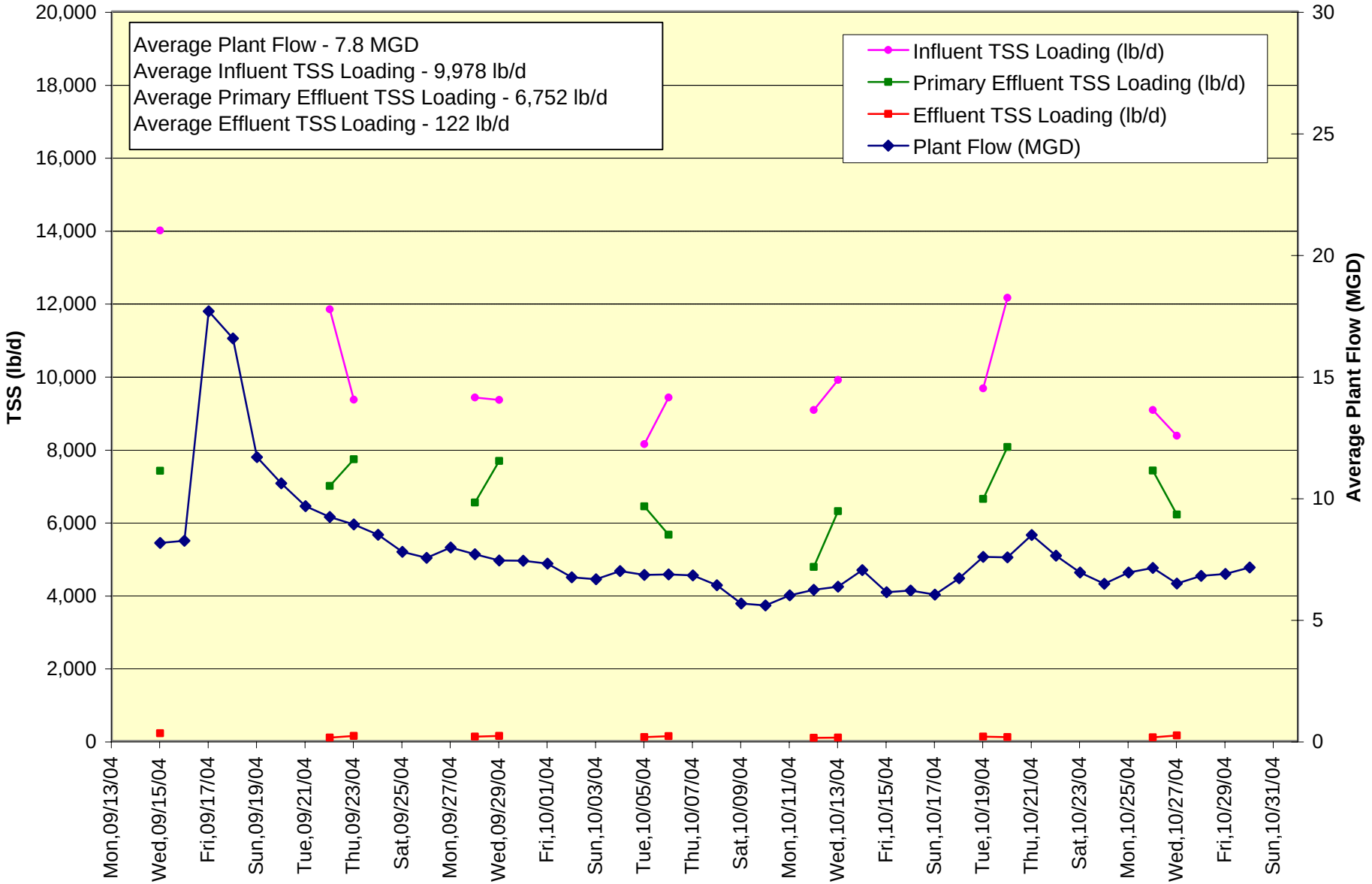

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FIGURE 4-4
SUBMETERING - TSS LOADING vs PLANT FLOW

TABLE 4-1 summarizes the process data collected during the submetering period. These parameters were compared to historical values. It can be seen in TABLE 4-1 that the averages from the submetering period are comparable with the historical averages for all parameters. Due to seasonal variations (mostly due to Cornell University's schedule), historical peak values are significantly higher than the corresponding peaks from the submetering period especially for influent BOD_5 and TSS loading, RAS suspended solids, and pumped digested sludge.

Table 4-1: Summary of IAWWTF Performance during the Submetering Period Compared to Historical Data

Parameter	Unit	Submetering		Historical [1]	
		Average	Maximum	Average	Maximum
Influent Plant Flow	MGD	7.8	17.7	6.8	16.7
Influent BOD_5 Concentration	mg/L	173	227	186	379
Influent BOD_5 Loading	lb/d	10,651	12,597	10,366	22,389
Primary Effluent BOD_5 Concentration	mg/L	109	138	111	175
Primary Effluent BOD_5 Loading	lb/d	6,665	7,876	6,327	11,595
Effluent BOD_5 Concentration	mg/L	16.1	22.0	14.4	31
BOD_5 Removal	%	90.7	93.8	91.8	97.8
Influent TSS Concentration	mg/L	162	206	172	688
Influent TSS Loading	lb/d	9,978	13,993	9,494	36,359
Primary Effluent Concentration	mg/L	110	128	92	229
Primary Effluent Loading	lb/d	6,752	8,058	5,192	10,344
Effluent TSS Concentration	mg/L	2.0	3.1	2.1	10.2
TSS Removal	%	98.8	99.2	98.5	100
WAS Flow	MGD	0.22	0.25	0.18	0.33
RAS Flow	MGD	4.10	5.45	NA[2]	NA[2]
RAS Suspended Solids	mg/L	3,621	9,384	3,439	22,440
Septage Percent Solids	%	2.5	5.1	2.3	14
Thickened Sludge Percent Solids	%	2.8	3.9	3.3	5.9
Pumped Digested Sludge	Gpd	34,971	43,880	37,777	111,750
Belt Filter Press Feed Percent Solids	%	3.58	3.70	3.39	5.60
Cake Percent Solids	%	22.8	24.1	22.0	24.0

Note:
1. Historical data from 2002 and 2003
2. Based on discussions with plant personnel, historical RAS flow was manually controlled such that it was maintained at an average range of 3.5 to 4.0 MGD.

4.2 RELATIONSHIP BETWEEN PLANT PROCESS DATA AND SUBMETERING DATA

4.2.1 Main Influent Wastewater Pumps

Electric energy usage in kilowatt-hours (kWh) for the two pumps with VFDs (one pump operated during average flow conditions; two pumps operated during high flow conditions) was recorded in 15-minute intervals during the submetering period (September 15, 2004 to October 31, 2004).

Total electric energy demand for the influent wastewater pumps is the algebraic sum of the electric energy demand for the two influent wastewater pumps. FIGURE 4-5 shows a comparison of the average daily flow and the total electric energy demand by the two influent wastewater pumps during the submetering period. During this period, flow ranged from approximately 5.6 MGD on October 10, 2004 to a peak of 17.7 MGD on September 17, 2004. FIGURE 4-5 shows a good correlation between total flow and electric energy demand indicating that the electric energy usage by the influent pumps is dependent upon flow rate, i.e., the greater the influent flow rate, the greater the pumps' electric energy usage. Significantly higher flows were observed due to precipitation on September 17, 2004 (National Weather Service, Binghamton website) that resulted in greater electric energy demand. As expected, the total amount of electric energy used by the wastewater pumps is proportional to the influent wastewater flow.

4.2.2 Return Activated Sludge Pumps

The IAWWTF has five RAS pumps, all of which have VFDs. Two pumps are typically in operation; hence continuous submeters were installed on two pumps with VFDs. The use of VFDs allows pumps to operate at their most efficient points. Energy usage in kilowatt-hours for two pumps (with VFDs) was recorded during the submetering period (September 15, 2004 to October 31, 2004).

During the submetering period, the RAS pumps conveyed an average flow of approximately 4.1 MGD to the secondary process. FIGURE 4-6 shows a comparison of the RAS flow and electric energy demand by the RAS pumps during the submetering period. As expected, the data on FIGURE 4-6 show a good correlation between total RAS flow and electric energy usage indicating that the electric energy usage by the RAS pumps is dependent upon RAS flow rate.

4.2.3 Aeration Blowers

Secondary treatment consists of four aeration basins, each having a volume of 0.5 MG and a fine bubble diffuser system. There are four 125-hp centrifugal blowers. The blowers are manually controlled by adjusting the blower inlets based on readings from the dissolved oxygen (DO) meters. The aeration basins are operated in plug flow mode. FIGURE 4-7 shows a comparison of the total delivered air flow to the four aeration tanks and the total electric energy demand of the two aeration blowers. The blower electric energy demand correlates well with the delivered air flow and both show a slight diurnal variation likely due to manual blower adjustments by plant staff. FIGURE 4-8 shows a comparison of the DO measured at the head of each of the four aeration tanks and the delivered air flow. From FIGURE 4-8 it can be seen that the DO concentrations vary significantly in a diurnal pattern, while the air flow only varies slightly. Bi-hourly BOD_5 samples of the aeration system influent were taken over a two-day period during the submetering period. FIGURE 4-9 shows a comparison of the DO measured at the head of each of the four aeration

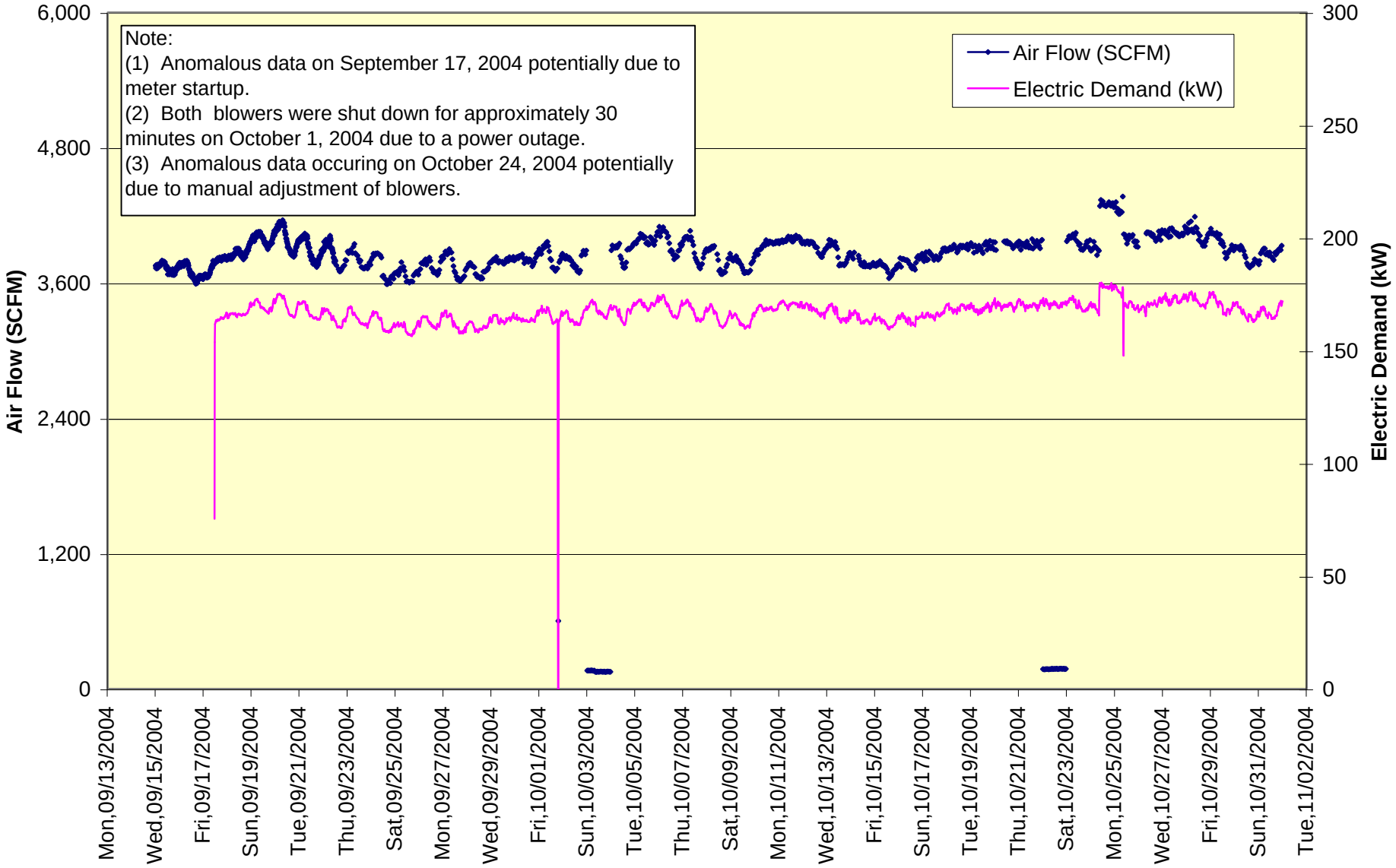

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FIGURE 4-7
AERATION TANK DELIVERED AIR FLOW vs TOTAL ELECTRIC DEMAND BY AERATION BLOWERS

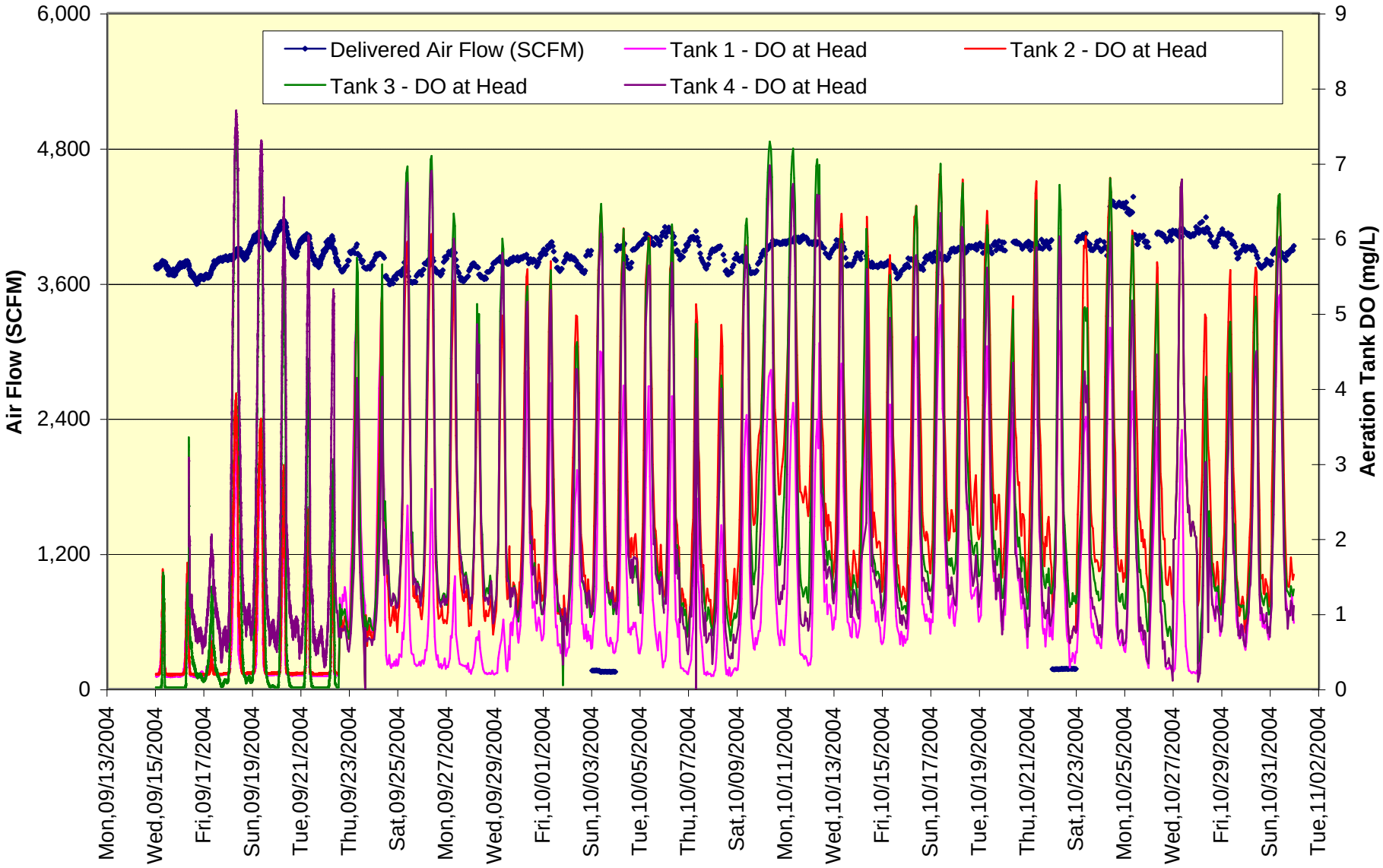

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FIGURE 4-8
AERATION TANK DISSOLVED OXYGEN vs DELIVERED AIR FLOW

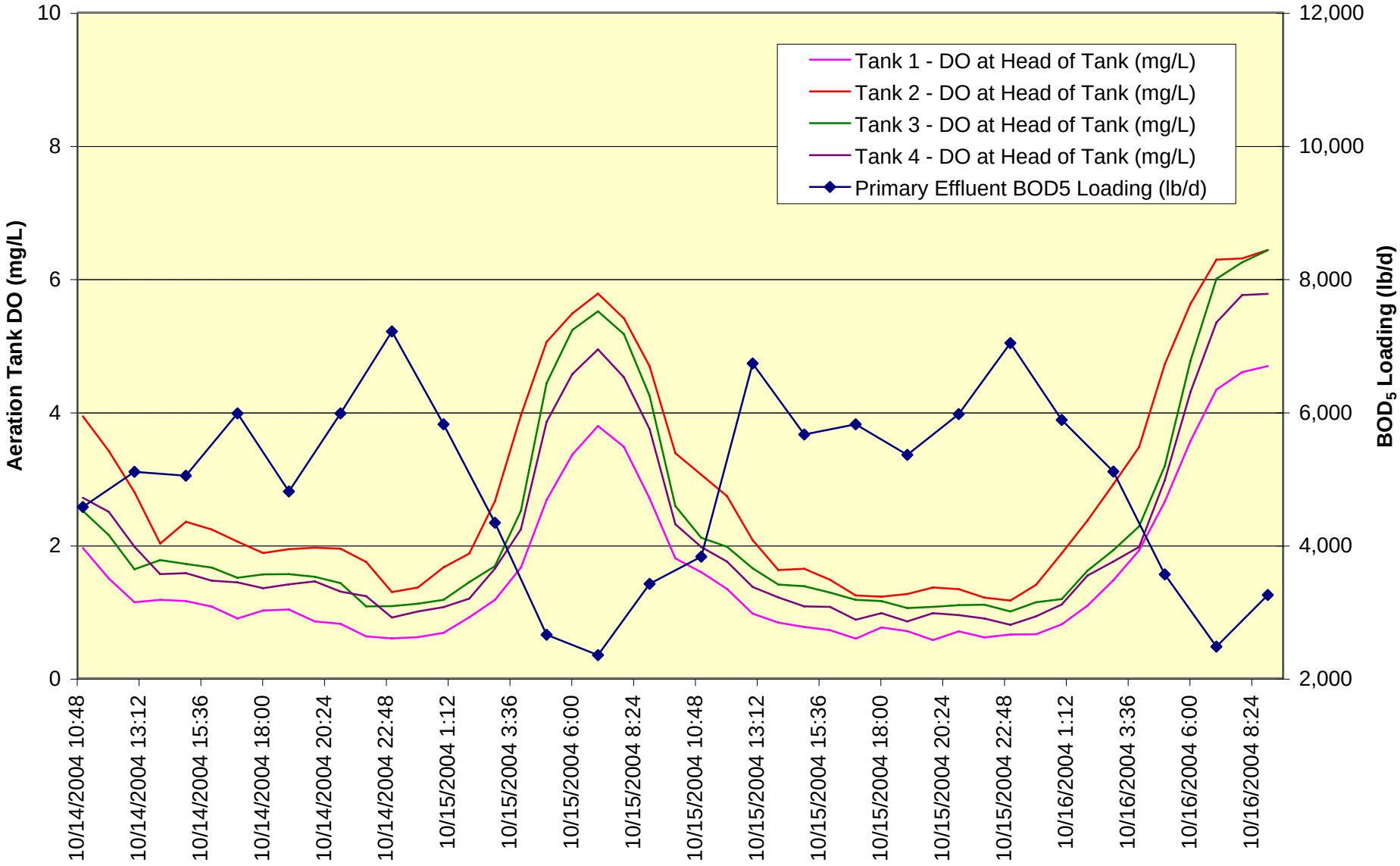

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FIGURE 4-9
AERATION TANK DISSOLVED OXYGEN vs PRIMARY EFFLUENT BOD_5 LOADING

tanks and the primary effluent BOD_5 loading for the two-day period during submetering while FIGURE 4-10 compares the DO concentrations and delivered air flow for the same two-day period. From FIGURES 4-9 and 4-10, it is seen that the measured DO increases as the primary effluent BOD_5 decreases particularly during the night, while the air flow rate delivered remains relatively consistent. Because the blower operation is only adjusted during the day (when the plant is staffed), the increased DO concentration are likely a result of the lower BOD_5 and corresponding lower oxygen demands observed at night when blower operation is unmodified.

4.2.4 Solids Handling

The following equipment and processes are associated with the solids handling at the IAWWTF:

- Thickening
- Digestion
- Dewatering
- Disposal

Primary and secondary sludge is blended and pumped to two gravity thickeners. Percent solids in the thickened sludge averaged approximately 2.8% during the submetering period. The thickened sludge is then pumped to two digesters, and the average pumping rate was 49,140 gallons per day (gpd) during submetering. An average of 25,400 gpd of septage was pumped into the digester during the submetering period at an average percent solids of 2.5%. This average is based only on days when septage is received.

The digested sludge is pumped to the belt filter press. The belt filter press was continuously submetered to identify actual operating times for the equipment. FIGURE 4-11 shows a comparison of the electric energy demand and the percent solids in and out of the belt filter press. It can be seen from FIGURE 4-11 that the belt filter press normally operates on weekdays (Monday through Friday) for about 8 hours a day (7AM to 3 PM). Digested sludge going into the belt filter press had an average percent solids of 3.6% during the submetering period. Percent solids in the sludge cake leaving the belt filter press averaged 22.8% during the submetering period. The solids percentages are typical numbers at the plant based on historical data. FIGURE 4-12 compares belt press electric energy demand to belt press influent solids loading. As expected, the belt filter press operates at relatively constant rate and the belt filter press electric demand is not influenced by the solids loading.

4.2.5 Digester Gas Co-Generator

Digester gas is typically used to run two 110-kW capacity generators and also to supply a boiler for plant heat. Both co-generators were continuously submetered; however, typically only one co-generator is

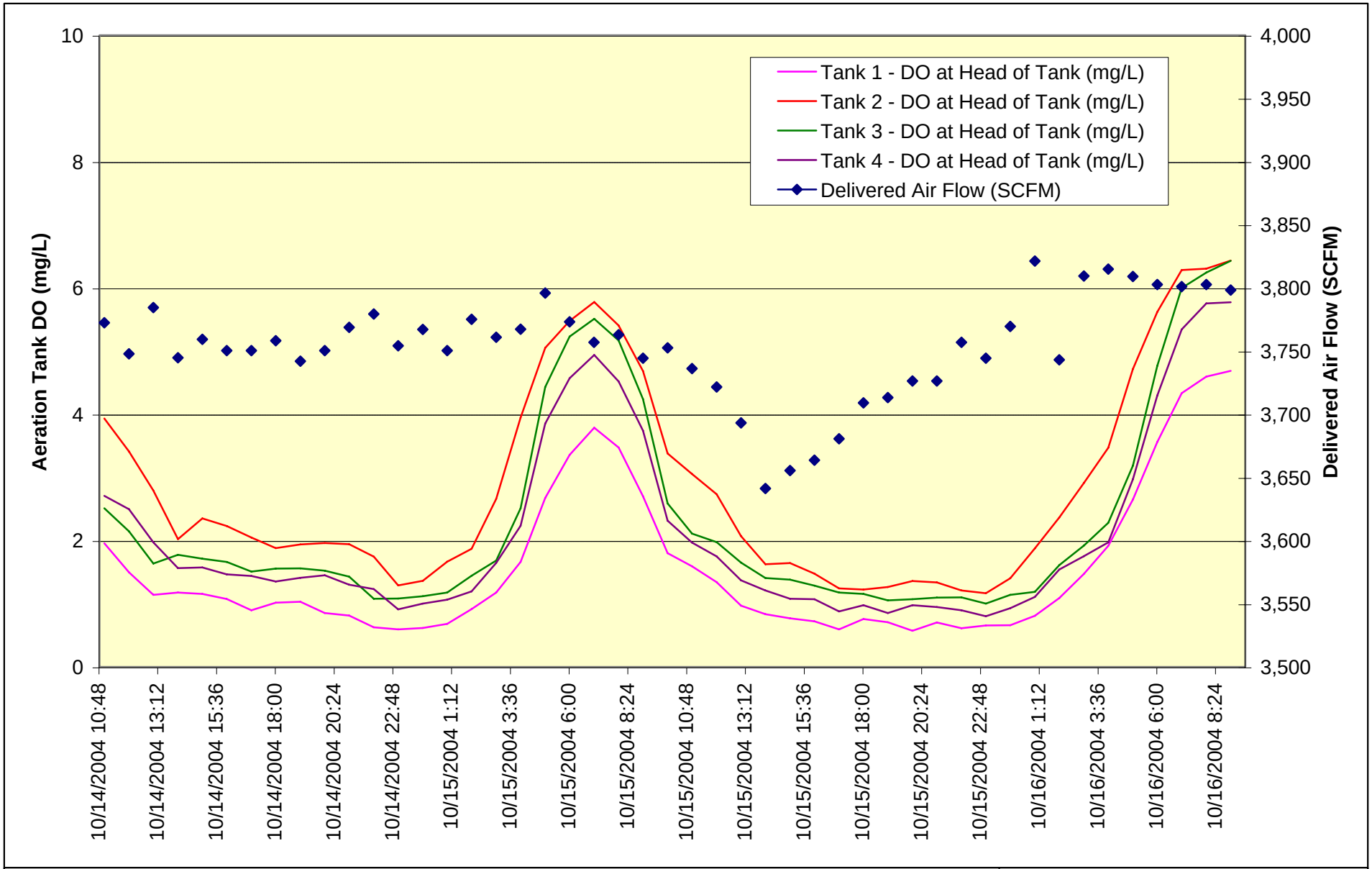

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FIGURE 4-10
AERATION TANK DISSOLVED OXYGEN vs DELIVERED AIR FLOW

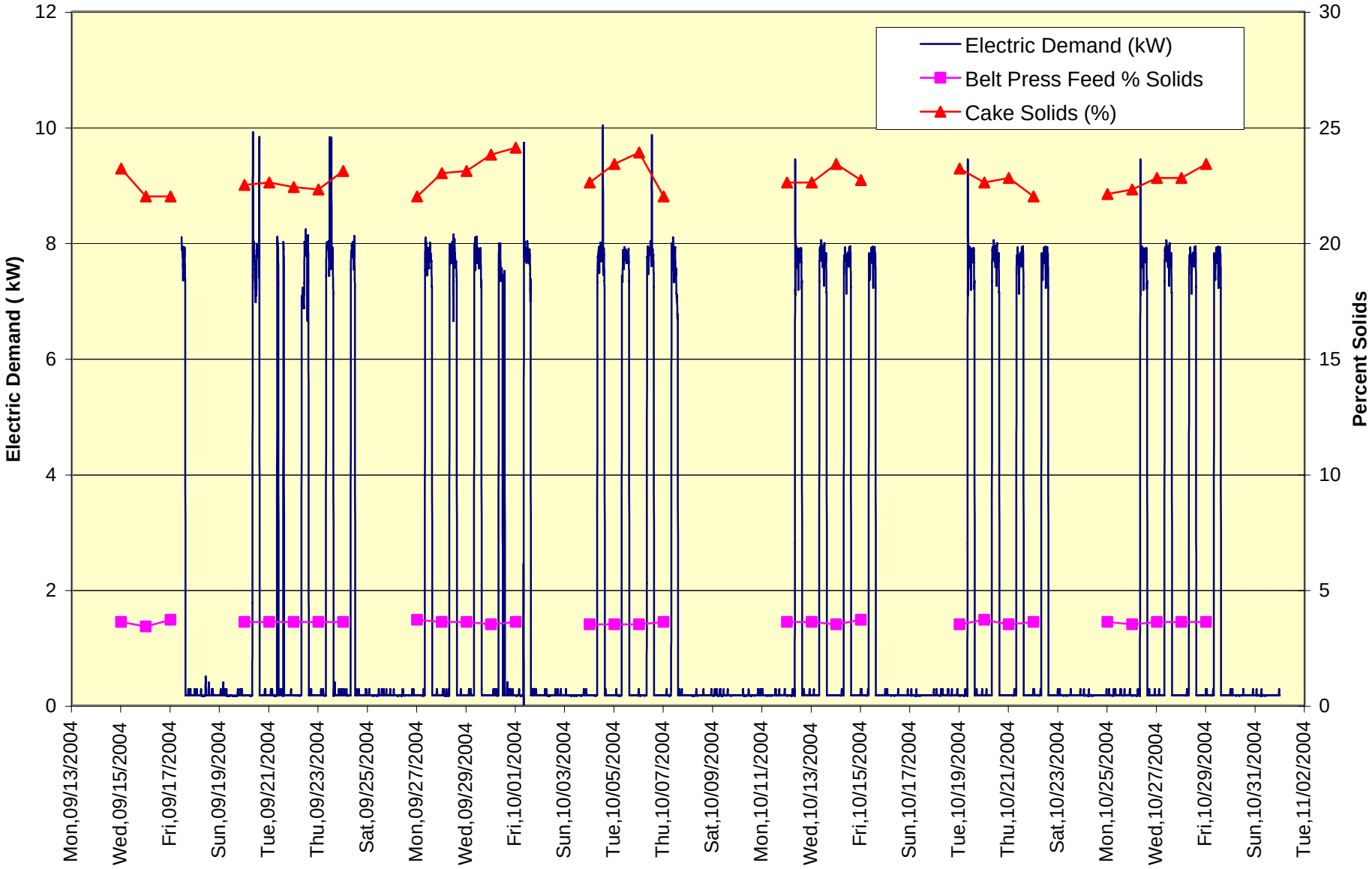

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FIGURE 4-11
PERCENT SOLIDS vs TOTAL ELECTRIC DEMAND BY BELT FILTER PRESS

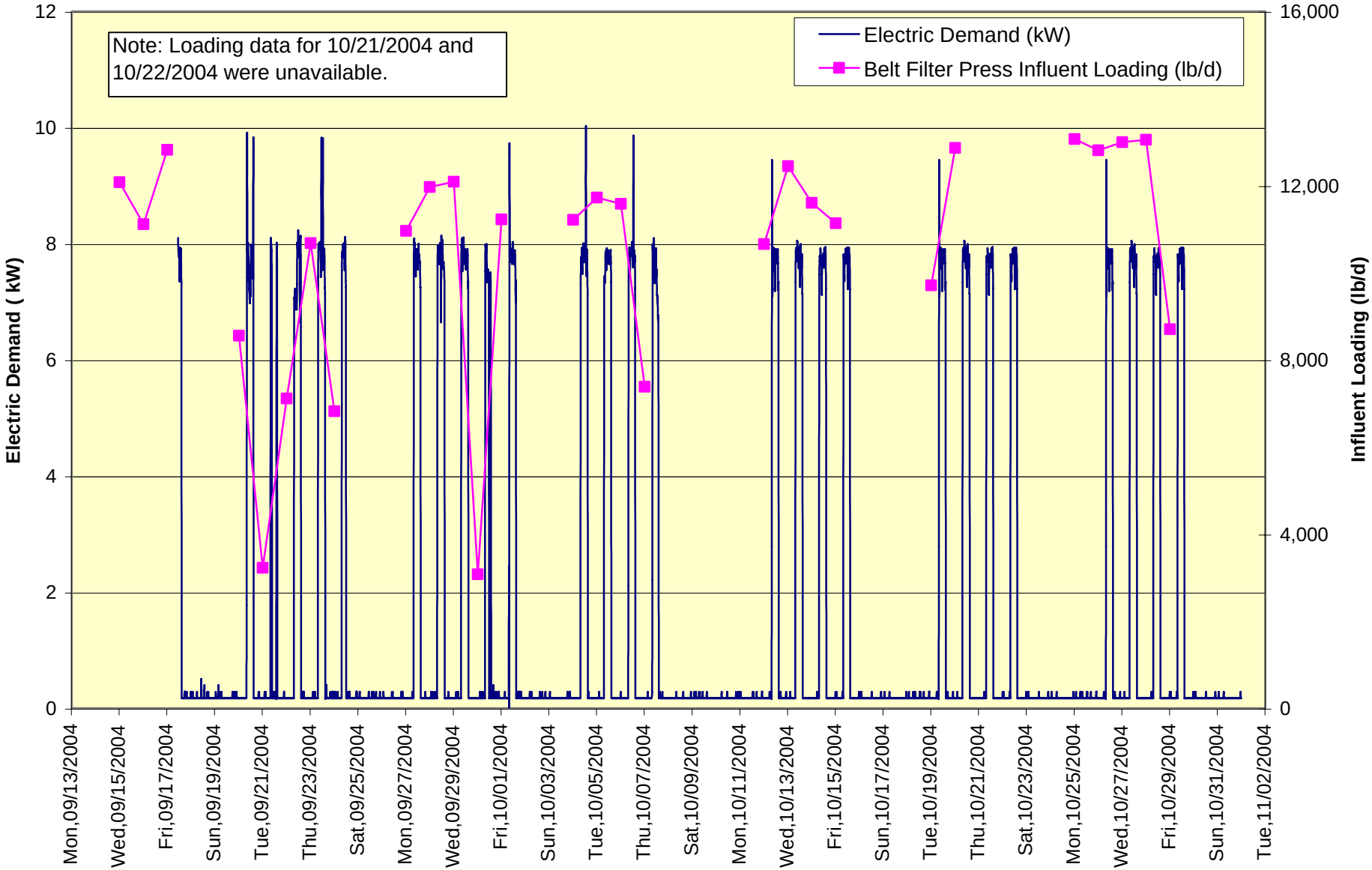

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FIGURE 4-12
BELT FILTER PRESS LOADING vs TOTAL ELECTRIC DEMAND BY BELT FILTER PRESS

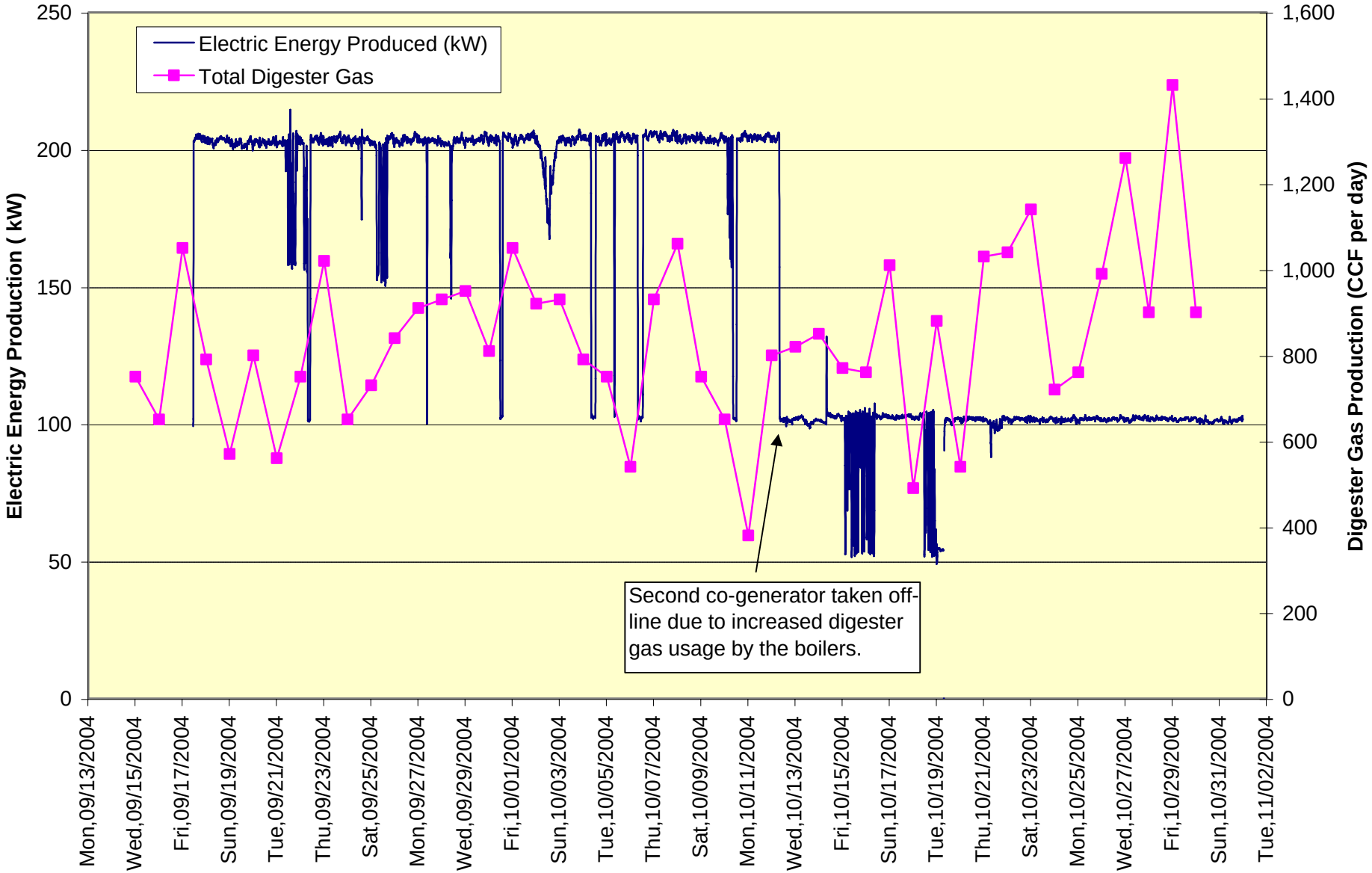
operated. If sufficient methane is available, a second co-generator will be brought online as was the case during the submetering period. FIGURE 4-13 shows a comparison of the digester gas produced and the total electric energy produced by the generators during the submetering period. An average of 839 hundred cubic feet (CCF) per day (equivalent to 503.4 therms assuming a heating value of 600 BTU per cubic foot of digester gas) of digester gas was produced during the submetering period. FIGURE 4-13 shows that the second co-generator was taken off-line on October 19, 2004, which is a result of increased digester gas usage by the boilers (i.e., less digester gas available for use by the co-generators).

4.2.6 Other Equipment

As indicated in Section 3, other equipment at the plant includes:

- Mechanical Bar Screens
- Lighting
- Exhaust Fans
- Circulation Pumps
- Sumps

For the above mechanical equipment, the small size of the associated motors, the relatively low standard efficiencies of smaller motors, and/or the low frequency of use have indicated that any further evaluation of this equipment would most likely not yield significant cost savings.



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ITHACA AREA WASTEWATER TREATMENT FACILITY

FIGURE 4-13
TOTAL GAS PRODUCTION vs TOTAL ELECTRIC ENERGY PRODUCED BY COGENERATORS

Section 5

ENERGY SAVING MEASURES THROUGH CAPITAL IMPROVEMENTS

5.1 CAPITAL IMPROVEMENT ALTERNATIVES TO REDUCE ENERGY USAGE AND COSTS

Section 4 evaluated the major equipment in use at the Ithaca plant and compared energy usage to process performance. The detailed process and electric energy usage information collected during the submetering period was used to identify and evaluate energy conservation opportunities at the Ithaca Area Wastewater Treatment Facility (IAWWTF). Potential energy saving opportunities are discussed in this section.

5.1.1 Installation of Automatic Controls on the Aeration System Blowers

The IAWWTF currently employs manual control of the centrifugal blowers to adjust the dissolved oxygen (DO) concentration in the aeration basins. This approach relies on DO readings gathered by DO probes located within the aeration basins. Based on the results of the initial site visit, replacing the current probes in the aeration tanks with newer monitoring technologies and providing an automatic control system for adjusting blower operations based on DO readings could result in potential energy savings. New DO probes, based on luminescent technology, have already been installed at the head of two of the four aeration tanks at the plant.

5.1.2 Switching From Ferrous Chloride to Ferric Chloride Use for Phosphorus Removal in the Aeration Basins

Based on discussions with IAWWTF personnel, the plant currently uses ferrous chloride and a target DO concentration of 6 milligrams per liter (mg/L) to 8 mg/L in their aeration basin to achieve phosphorus removal. Ferrous is oxidized to ferric in the aeration basin and incurs an oxygen demand for this chemical reaction. Thus, there may be a potential to reduce the target DO concentration in the basins by switching to ferric chloride by eliminating this oxygen demand. A cost savings would be associated with this approach due to reduced electric energy consumption of the aeration system blowers.

5.2 ESTIMATE OF ENERGY USAGE, DEMAND, AND COST SAVINGS

The following section summarizes the estimated energy usage of the described alternatives, as well as estimates of energy and cost savings associated with the improvements.

5.2.1 Installation of Automatic Controls on the Aeration System Blowers

In order to estimate the electric energy savings associated with this alternative, a comparison was made between the electric energy usage for the existing practice of manual adjustment of the aeration blowers and the projected electric energy usage of the proposed automatic control system. As shown on FIGURE 4-8, the residual DO concentration in the aeration tanks at the plant varies throughout the day. This variation is most significantly due to the fact that air feed to the tanks is accomplished through manual control and not adjusted during night time hours when the plant is not staffed and air demand decreases. Electric energy savings were estimated by assuming that automatic control of air feed to the tanks would dampen the peaks in residual DO concentrations. Through the use of an automatic control system, a target residual DO concentration in the aeration tanks could be maintained. The energy savings would be realized through reduced aeration blower electric energy usage. A residual DO concentration of 1 mg/L at the tail of the aeration tanks was assumed for the purposes of estimating electric energy savings.

For this evaluation, the existing electric energy usage was estimated by obtaining the aeration blower input horsepower from the performance curve (FIGURE 5-1) using the average air flow rate recorded during the submetering period. The average air flow rate during the submetering period was 3,820 standard cubic feet per minute (scfm), which corresponds to an electric energy demand of 65 kW (87 hp). Assuming a premium motor efficiency of 94% for the 125-hp centrifugal blowers, this corresponds to an electric energy demand of 69 kW. In comparison, the average electric energy demand measured during the continuous submetering data period was 84 kW. The difference between the estimated and submetered electric energy demand may be attributed to error in air flow measurements and/or the air temperature/density difference between standard (performance curve) and field (actual measurements) conditions that are not accounted for in this evaluation. Extrapolating the estimated demand developed from the performance curve (69 kW – corrected for 94% motor efficiency) to an entire year assuming 24 hours per day/seven days per week operation, corresponds to an estimated electric energy usage of 1,208,880 kWh per year. By comparison, the electric energy usage based on submetering data is 1,462,857 kWh per year.

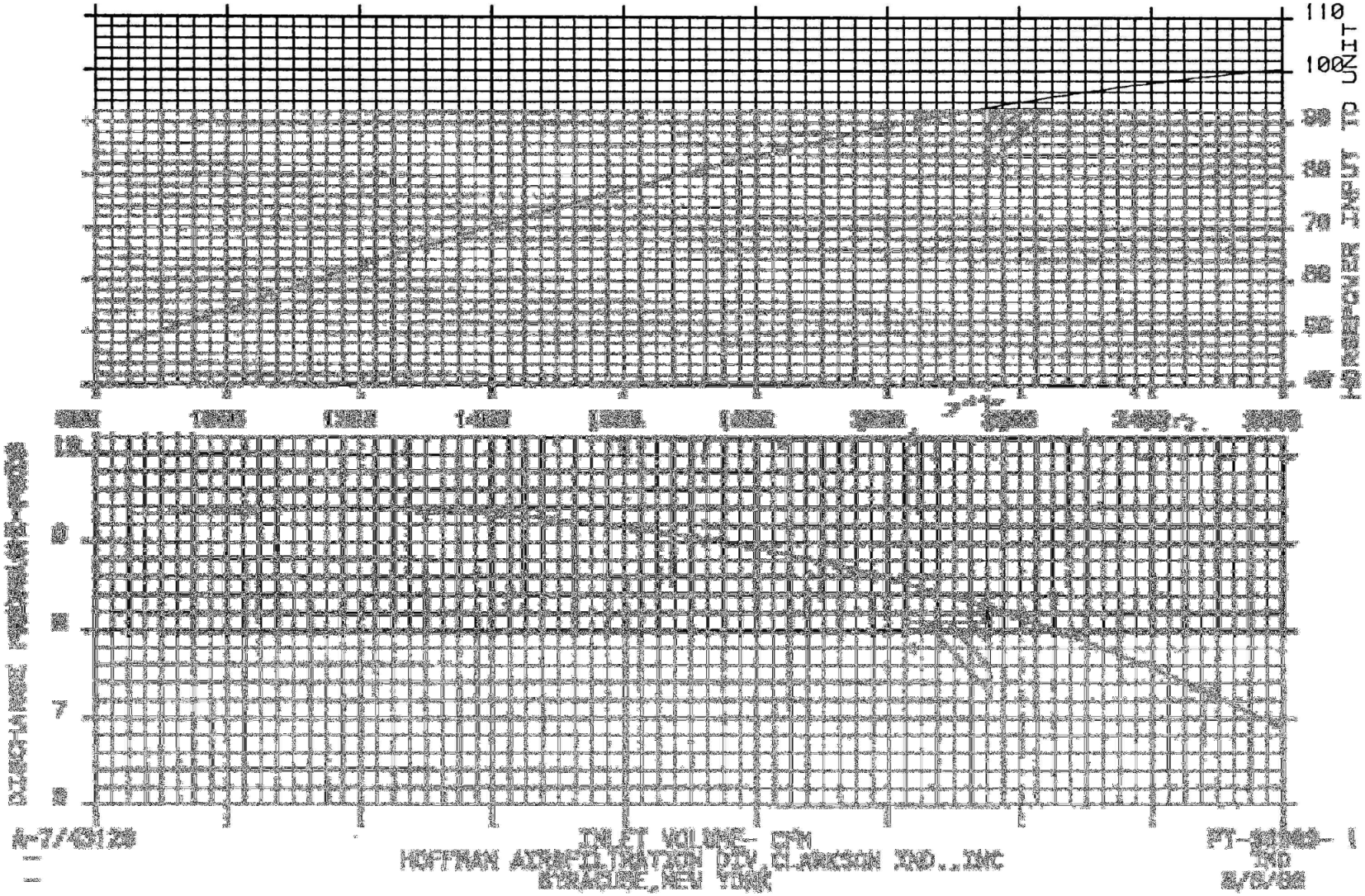
To estimate the electric energy savings associated with using an automatic control system, standard oxygen transfer efficiency equations were used to predict the air flow rate required to achieve a target residual DO concentration of 1 mg/L. A ratio was then estimated between the air demand for the target DO concentration and that of each incremental DO reading recorded during the submetering period. The ratio would indicate the additional air demand needed for DO concentrations in the data set below the target point of 1 mg/L, as well as the magnitude of air demand reduction for DO concentrations above the target point. These ratios were applied to the recorded air flow rate to determine the predicted air flow rate under an automatic control system, and an average air flow rate was estimated as 3,060 scfm. Through the use of the aeration blower curve, this air flow rate corresponds to electric energy demand of 56 kW (75 hp).

PERFORMANCE CURVE CENTRIFUGAL BLOWER
FRAME SIZE:74107A1
PLOT CONDITIONS
1:14.48 Psia Atm,14.48at unit 100 DegF 3550 RPM

Gas Data: SG=1.000 K= 1.40 M=28.95 RH= 36

CERTIFIED CORRECT FOR:
ITHACA WWTP
ITHACA, NY
CUSTOMER ORDER NO:5569
HOFFMAN ORDER NO:GS-33383A
BY: Tina M. Davis

SERIAL #:0585002
TEST #:A-86147



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION ITHACA AREA WASTEWATER TREATMENT FACILITY	FIGURE 5-1 Aeration Blower Performance Curve

Assuming a premium motor efficiency of 94%, this corresponds to 60 kW. Extrapolating this to an entire year assuming 24 hours per day/seven days per week operation, this corresponds to an estimated electric energy usage of 1,051,200 kWh per year with the implementation of an automatic controls system.

The estimated energy savings based on the theoretical blower demand of 69 kW are 157,700 kWh, while the estimated energy savings based on the submetered blower demand can be as high as 411,700 kWh. For the purpose of the economic evaluation of the recommended improvements, the theoretical blower energy demand estimates were used to be consistent with the estimates of the energy demand for the future proposed conditions (which were also based on the theoretical readings from the blower performance curve). This approach also results in a more conservative estimate of the projected energy savings. The blower performance and condition, however, should be further investigated during the implementation of the proposed improvements. These investigations may assist in improving the blower efficiency and potentially closing the gap in theoretical and measured energy demand, which may result in additional energy savings.

Assuming an electric energy billing rate of $0.093 per kWh, this translates to an estimated savings of $14,700 per year.

5.2.2 Switching From Ferrous Chloride to Ferric Chloride Use for Phosphorus Removal in the Aeration Basins

Determination of cost savings associated with switching to ferric chloride for phosphorus removal involves estimating the amount of oxygen that is required to oxidize ferrous to ferric under current operations. Considering the use of ferric chloride would eliminate the need for iron oxidation, the actual cost savings is represented by the electric energy used by the aeration system air blower to generate this amount of oxygen.

Approximately 333 pounds per day of ferrous chloride, as iron, are applied to the aeration basins for phosphorus removal (based on year 2002 and 2003 data). Based on this average chemical usage, information gathered from the IAWWTF's chemical supplier (Gulbrandsen Technologies, Clinton, NJ), as well as known stoichiometric relationships, the estimated amount of oxygen required for oxidation of ferrous chloride to ferric chloride is 95 pounds per day. This quantity of oxygen is negligible relative to the overall oxygen demand in the plant's secondary treatment system, and should not provide any noticeable electric energy savings for the aeration blowers.

The IAWWTF currently pays approximately $0.28 per pound of ferrous chloride, as iron. A budgetary cost estimate for ferric chloride, as iron, was obtained for approximately $0.52 per pound. Based on this budgetary information, switching to ferric chloride would result in increased chemical supply cost.

Considering the associated negligible aeration blower electric energy savings cost savings, it is recommended that the IAWWTF continue use of ferrous chloride for phosphorus removal.

5.3 ESTIMATE OF CAPITAL COSTS AND SIMPLE PAYBACK

5.3.1 Installation of Automatic Controls on the Aeration System Blowers

The estimated capital cost for an automatic control system for the aeration blowers and basins is $14,400 for all four aeration basins (based on manufacturer's quote with installation, plus 15% contingencies). This estimate includes installation of two motorized air damper valves, panel controls, and programming costs. Based on discussions with plant personnel, two of the four aeration tanks have motorized air damper valves and two do not. Plant personnel also indicated that there is capacity on the existing PLC controller to accommodate the panel controls associated with the automatic system. Thus, a new controller would not be necessary. It is assumed that the new DO probes already installed in two of the aeration tanks at the plant would provide adequate data for automatic control. Additional DO probes would not be necessary.

Based on the estimated savings of $14,700, the payback period would be approximately one year. Considering the short payback, it is recommended that the IAWWTF implement the automatic control system measure.

5.3.2 Conversion from Ferrous Chloride to Ferric Chloride Use for Phosphorus Removal in the Aeration Basins

As stated previously, converting to ferric chloride would provide negligible electric energy savings at an increased chemical costs. Therefore, it is recommended that the IAWWTF continue use of ferrous chloride for phosphorus removal. Capital costs associated with this measure are not included in this report.

5.4 ADDITIONAL DISCUSSION: PREMIUM EFFICIENCY MOTORS

Based on discussions with plant personnel, all motors for equipment of 5 hp or greater have premium efficiency motors. These motors were installed when the IAWWTF was constructed in 1986. Therefore, there is no potential for electric energy savings associated with replacement of standard efficiency motors with premium efficiency motors.

Evaluation of energy saving measures through capital improvements to the plant's electric co-generation facilities are discussed in Section 8 of this report.

Section 6

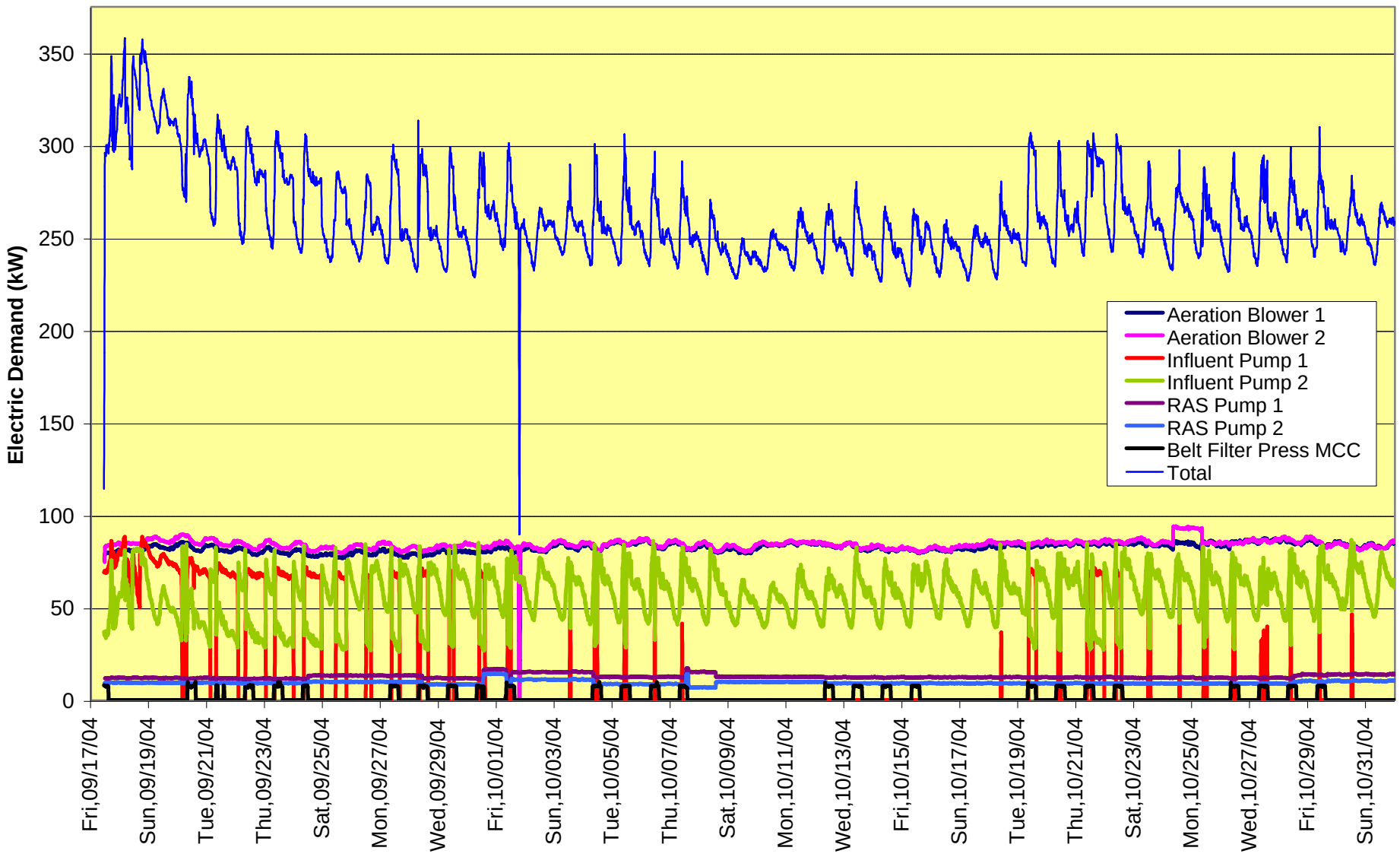
ENERGY SAVING MEASURES THROUGH OPERATION MODIFICATIONS

6.1 OPERATIONAL MODIFICATIONS TO REDUCE ENERGY USAGE

Typically, the major operational changes that can be made to reduce electric energy usage are load shifting, peak shaving, and greater use of real-time data in energy-related decision making. Load shifting is the practice of changing the time of use of certain loads to reduce the total facility electric energy demand during peak periods. Peak shaving is the practice of dispatching on-site generating assets to reduce dependence on the grid during peak demand periods. The increased use of real-time data by the installation and monitoring of permanent submeters can assist the facility in making informed decisions regarding the usage of energy and offer alternatives for further reducing energy usage and demand.

6.1.1 Load Shifting

Electric energy demand data collected at the Ithaca Area Wastewater Treatment Facility (IAWWTF) were used to estimate typical daily power draw. These data were then used to estimate when peak electric energy demand occurs at the plant. FIGURE 6-1 shows the electric energy demand for the submetered equipment during the submetering period. Note that the data presented are for continuously submetered processes only, and do not include other miscellaneous electric loads such as lighting, heating, ventilation and air conditioning (HVAC), and anaerobic digester equipment. As observed on FIGURE 6-1, regular peaks in energy demand for the influent pumps are observed. This pattern is attributed to the diurnal variation of influent flows to the plant. The electric energy demand for the solids handling system, as measured on the belt filter press motor control center (MCC), also shows a regular pattern of peaks. However, this is attributed to the sludge dewatering schedule (typically four to five days per week, approximately eight hours per day). Significant, regular peaks are generally not observed in the electric demand for the remaining individual submetered equipment, as well as the total demand for the submetered equipment. However, there are several pieces of equipment which were not submetered continuously under this project that are being used only during the day shift (which is also true for lighting and HVAC equipment). Therefore, the energy usage demand peaks during the day may be even more pronounced. At the same time, shifting any equipment or process operation to the second and third shift is not feasible as the plant is only staffed during the first shift. Any energy demand savings associated with load shifting will be greatly offset by substantial increases in labor costs. Considering this information, opportunities for further load shifting at the IAWWTF are not apparent.



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ITHACA AREA WASTEWATER TREATMENT FACILITY

FIGURE 6-1
ELECTRIC ENERGY DEMAND
SUBMETERED EQUIPMENT

6.1.2 Peak Shaving

Peak shaving refers to the practice of reducing demand during peak demand periods by using on-site generation capabilities.

The IAWWTF operates two 110-kilowatt (kW) Caterpillar combine heat and power (CHP) co-generator units. These units are primarily operated to utilize the available methane gas from the anaerobic digester. A more detailed description of the existing operation scheme for the co-generator units, as well as an evaluation of energy saving measures through capital improvements to the existing co-generation facilities, is provided in Section 8. These measures would allow for increased utilization of digester gas and increased electric energy generation, which would further reduce overall plant demand.

The IAWWTF also has an 800-kW stand-by diesel generator. It is possible that the emergency generator could be put into operation during periods of higher demand (e.g., during wet weather conditions) or peak shaving purposes. However, this is not an option at the IAWWTF for the following reasons:

- This emergency generator is permitted for emergency use and it is expected that the New York State Department of Environmental Conservation (NYSDEC) will only allow it to operate 500 hours annually in its current classification.

- The current New York State Electric and Gas Corporation (NYSEG) electric tariff SC-7, approved by the Public Service Commission, does not economically allow emergency or backup generators to be used for peak shaving. With the exception of some small systems and/or some renewable fuel systems, the SC-7 tariff requires the payment of several charges that can be very punitive.

- Air permitting for generating systems is required through the environmental agencies such as the New York State Department of Environmental Conservation and the Federal Environmental Protection Agency. A facility using a generator for non-emergencies, such as peak shaving, would be required to submit a study as to the amount of emissions of not only the generators, but all systems, such as boilers and heaters currently on site. Total emissions would not be allowed to exceed certain levels and the facility, as a whole, would need to conform. Diesel or natural gas powered generators with a maximum mechanical power rating of less than 400 brake horsepower would be exempt; however, the IAWTF has an 800-kW stand-by diesel generator, and therefore, would not qualify for the exemption.

- Futhermore, any peak demand charges associated with increased wet weather flows to the plant may happen during any time of the day. Based on discussions with plant operator personnel, even

if the plant were allowed to make use of the emergency generator for peak shaving purposes, the generator could not be operated during the second and third shifts because the plant is not staffed; two operators would be required to work overtime to operate the generator. The additional labor costs, as well as the generator fuel costs would significantly offset the energy savings associated with peak shaving.

After evaluating electric energy demand for submetered processes, there appear to be no peak shaving opportunities other than the co-generation improvement measures evaluated in Section 8.

6.1.3 Operational Modifications

Based on current operations and communications with the staff, no modifications to the operation of the plant are recommended.

Section 7

ENERGY SAVING MEASURES THROUGH LIGHTING/HVAC MODIFICATIONS

7.1 OVERVIEW

7.1.1 Heating, Ventilating, and Air Conditioning Overview

The Ithaca Area Wastewater Treatment Facility (IAWWTF) is comprised of one large building (Main Building) and two small buildings (Influent Pump and Stand-by Generator Buildings). Based on discussions with plant personnel, the total square footage of the three buildings is approximately 56,000 square feet. Each building is occupied by plant operator and maintenance staff from 6:00 AM through 4:00 PM, seven days per week.

The primary heating system for the Main Building is comprised of one H.B. Smith 2,500 MBH (1 MBH = 1,000 British Thermal Units per hour) hot water boiler, and two 7,000 MBH H.B. Smith hot water boilers. One of the larger boilers is damaged and inoperable. The boilers are supplemented by waste heat recovered from two 110-kilowatt (kW) Caterpillar co-generator units. The co-generator units primarily operate on methane gas recovered from the anaerobic sludge digestion process. These systems supply hot water to cabinet heaters, unit heaters, baseboard fine tube, hot water coils in heating and ventilating units 3 through 9, and air conditioning units 1 and 2. The Barber Coleman direct digital control (DDC) heating, ventilation, and air conditioning (HVAC) control system is antiquated, and offers few advantages. The system does not have a central computer to modify schedules or set points. Rather, the system primarily operates off time clocks. The staff indicated that the air handling equipment operates without set-back 24 hours per day seven days per week.

The Influent Pump Building has an Electro Duct 330-kW electric boiler and two air handling units designated as “HV 1” and “HV 2”. The staff has indicated that the boiler has never operated due to the impact it would have on the plant’s utility budget. The system is also supplemented by the primary heating system. HV 1, which serves the screening room, has a capacity of 9,075 cubic feet per minute (cfm) and is equipped with a hot water coil. A manual wall thermostat in the screening room indicated a 70 degree Fahrenheit (^{o}F) temperature set point during the site walkthrough. HV 2, which serves the HVAC equipment room, has a capacity of 3,820 cfm and is also equipped with hot water heat. This space also appeared to be maintained at 70 ^{o}F. The equipment room also has two unit heaters and two exhaust fans.

The Stand-by Generator Building was not accessed during this study; the staff indicated that there was no major HVAC equipment in the building.

7.1.2 Lighting Overview

The facility has approximately 450 2-foot by 4-foot, T-12, two-lamp magnetic ballast fixtures. These fixtures are inefficient and could benefit from a retrofit. High bay and incandescent fixtures are also present in the facility.

7.2 HVAC AND LIGHTING ALTERNATIVES TO REDUCE ENERGY USAGE AND COSTS

7.2.1 Heating, Ventilation, and Air Conditioning

This facility demonstrates one main area for HVAC energy saving opportunities: replacement of existing HVAC controls. Installation of an Energy Management System with a Windows-based front end is recommended. The new system would provide a graphic user interface (GUI) capable of scheduling temperatures, runtimes, alarming, hot water reset on boilers, and point trending. A load management program would also be recommended in this system. The load management system would cycle the co-gen units based on site demand, fuel price, and methane availability. The system could also assist in determining engine maintenance. TABLE 7-1 summarizes the preliminary estimate of costs, savings, and payback for these measures.

Table 7-1: Summary of Costs and Savings for HVAC Measures

Costs	**$ 75,000**
Savings	**$ 12,000**
Payback	**6.3 years**

7.2.2 Lighting

It is recommended that the existing lighting fixtures be replaced with 2-foot by 4-foot super T-8 electronic ballast fixtures. For every two incandescent bulbs, one two-lamp, 2-foot by 4-foot T-8 fixture should be installed. High bay 400 Watt fixtures should be replaced with 6L 4-foot by 4-foot T-8 fixtures. Occupancy sensors and controls are also recommended. TABLE 7-2 summarizes the preliminary estimate of costs, savings, and payback for these measures.

Table 7-2: Summary of Costs and Savings for All Lighting Measures

Costs	**$ 81,000**
Annual Savings	**$ 9,300**
Payback	**8.7 years**

Section 8
ON-SITE GENERATION

8.1 DESCRIPTION OF EXISTING SYSTEM OPERATION

The Ithaca Area Wastewater Treatment Facility (IAWWTF) currently operates two 110-kilowatt (kW) Caterpillar combine heat and power (CHP) generator units. These units are primarily operated to generate power from anaerobic digester gas. The power generated by the units is returned to the plant power grid.

Based on discussions with plant personnel, one generator runs 24 hours per day/seven days per week on digester gas under typical operations. During the winter months when a higher amount of digester gas is used by the boiler for plant heating and gas production at the plant is lower, there is typically only enough digester gas remaining to run one generator. During these periods, the other generator is shut down. However, during the summer months when a lower amount of digester gas is directed to the boiler and gas production at the plant is higher, the second generator is typically brought online for eight hours per day (during the first shift when the plant is staffed) to use the excess digester gas.

During periods of low digester gas feed to the generators, feed to the primary generator unit is automatically switched from digester gas to natural gas in order to keep at least one generator operational at all times. This switch-over, however, is not automatically reversible. If the switch-over to natural gas takes place during the evening hours when the plant is not staffed, digester gas is wasted to the waste gas burner even if digester gas pressure builds back up to a sufficient level overnight. In these instances, manual switch-over back to digester gas is required and typically performed when the plant staff returns in the morning.

The existing engines and heat exchangers for the co-generators are 1988 vintage. The engines have been routinely overhauled, and at the time of the audit they were found to be in good operating condition. IAWWTF staff performs a majority of the maintenance required for the generator units. Based on discussions with plant personnel, heat is not recovered from the stack, oil, or intercoolers of the units.

8.2 CAPITAL IMPROVEMENT ALTERNATIVES

The following three capital improvement alternatives for the co-generation system were evaluated as part of this report:

- Alternative 1: Installation of gas storage facilities and new controls with continued operation of the existing co-generator units.

- Alternative 2: Installation of gas storage facilities and new controls and replacement of the co-generator units with microturbines.

- Alternative 3: Installation of gas storage facilities and upgraded heat recovery and controls; in-kind replacement of the existing co-generator units with higher-efficiency reciprocating engines.

8.2.1 Alternative 1 Evaluation: Installation of Gas Storage Facilities and New Controls with Continued Operation of the Existing Co-Generator Units

This alternative includes the installation of gas storage facilities and new controls and continued operation of the existing co-generation units.

The proposed control system would allow for operation of the existing co-generation units, which have an approximate electrical efficiency of 28%, based on fuel price, facility electrical load, and the availability of digester gas. Gas storage facilities would allow for capture and subsequent usage of the digester gas that is currently wasted by the facility due to various operating modes. As described in Section 8.1, the primary loss is due to the lack of an automatic switch-over from natural gas to digester gas during the second and third shifts during periods of low digester gas production. The new controls would allow for operation of the secondary co-generator, as necessary, during the first shift when the plant is staffed to allow for processing of any digester gas captured in the storage facilities during the second and third shift. The storage needs were estimated based on data provided by plant operators of the quantity of wasted digester gas. The costs, savings, and payback for this alternative are summarized in TABLE 8-1.

Table 8-1: Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls with Existing Co-generator Units

Costs	**$173,500**
Annual Savings	**$29,114**
Payback	**6.0 years**

The capital cost for this alternative includes costs for controls, a 1,000-cubic foot digester gas storage tank, a gas scrubber, a compressor, and a moisture eliminator.

8.2.2 Alternative 2 Evaluation: Installation of Gas Storage Facilities and New Controls and Replacement of the Co-Generator Units with Microturbines

This alternative includes the installation of gas storage facilities and new controls and replacement of the co-generator units with microturbines. The existing co-generator units would be replaced with two 60-kW Capstone microturbines rated at 22% electrical efficiency to replace the existing reciprocating engines. Typically, the microturbines are not as efficient as the existing reciprocating engines, which have an approximate electrical efficiency of 28%. However, the microturbines do produce significantly higher values of recoverable waste heat per unit of electrical energy generated relative to the existing co-generator units. To match the facility heat requirements and optimize the microturbine efficiency, the microturbines would be sized smaller in terms of capacity. The new units would be equipped with heat recovery modules. Furthermore, emissions from a microturbine would likely be lower than those from the existing co-generator units, which may become an important consideration in the future if the New York State Department of Environmental Conservation (NYSDEC) decides to impose more stringent air emissions standards for biogas fueled distributed generation systems.

The proposed control system would allow for operation of the two microturbines based on fuel price, facility electrical load, and the availability of digester gas. Gas storage facilities would allow for capture and subsequent usage of the digester gas that is currently wasted by the facility due to various operating modes. As described in Section 8.1, the primary loss is due to the lack of an automatic switch-over from natural gas to digester gas during the second and third shifts during periods of low digester gas production. The storage needs were estimated based on data provided by plant operators of the quantity of wasted digester gas. The costs, savings, and payback for this alternative are summarized in TABLE 8-2.

Table 8-2: Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls and Replacement of the Co-generator Units with Microturbines

Costs	**$663,500**
Annual Savings	**$ 37,656**
Payback	**17.6 years**

The capital cost for this alternative includes costs for the microturbines, controls, a 1,000-cubic foot digester gas storage tank, a gas scrubber, a compressor, and a moisture eliminator. The facility would also have to outsource the maintenance on these units. This cost has been included in the payback for this alternative.

8.2.3 Alternative 3 Evaluation: Installation of Gas Storage Facilities and Upgraded Heat Recovery and Controls; In-Kind Replacement of the Existing Co-Generator Units with Higher-Efficiency Reciprocating Engines.

This alternative includes the installation of gas storage facilities and new controls and in-kind replacement of the co-generator units with higher efficiency reciprocating engines. The existing co-generator units would be replaced with two 100-kW, 1,200 revolutions per minute (rpm) Caterpillar co-generator units rated at 35% electrical efficiency. The new units would feature heat recovery from the exhaust, jacket water, oil and intercooler. The new engines have slightly better fuel efficiency and the enhanced heat recovery combine would yield significant energy savings.

The proposed control system would allow for operation of the two co-generator units based on fuel price, facility electrical load, and the availability of digester gas. Gas storage facilities would allow for capture and subsequent usage of the digester gas that is currently wasted by the facility due to various operating modes. As described in Section 8.1, the primary loss is due to the lack of an automatic switch-over from natural gas to digester gas during the second and third shifts during periods of low digester gas production. The storage needs were estimated based on data provided by plant operators of the quantity of wasted digester gas. The costs, savings, and payback for this alternative are summarized in TABLE 8-3.

Table 8-3: Summary of Costs and Savings for Installation of Gas Storage Facilities and New Controls and In-kind Replacement of the Co-generator Units with Higher Efficiency Reciprocating Engines

Costs	**$351,000**
Annual Savings	**$78,006**
Payback	**4.5 Years**

The capital cost for this alternative includes costs for new co-generator units, controls, a 1,000-cubic foot digester gas storage tank, a gas scrubber, a compressor, and a moisture eliminator.

8.3 LOAD CURTAILMENT

The IAWWTF also has an 800-kW stand-by diesel generator. As discussed in Section 6.1.2, using the generator for routine peak shaving is not feasible. However, it may be feasible to use the generator for load curtailment. The facility is currently not enrolled in any curtailment programs and does not receive any incentives for its operation. If the facility were to enter into contract with a New York Independent System Operator (NYISO)-approved curtailment provider, they would receive an incentive of approximately $3,600 per year and an event-based incentive of $0.30 per kilowatt-hour (kWh) of energy generated. The facility could also receive incentives of $40 per kW from NYSERDA for short term load reduction. There would be no initial cost associated with entering into a curtailment program and the incentive levels would change on an annual basis.

8.4 SUMMARY

The co-generator capital improvement alternatives discussed in this section offer advantages when compared to the operation of the existing co-generator units. However, considering the condition of the existing co-generator units, this investment is not recommended at this time.

At the end of the useful life cycle of the co-generator units currently used (8 to 10 more years, approximately), it may be feasible to replace them with newer-generation equipment, such as micro-turbines or other new technology available at that time, which may be more efficient than the existing co-generators. The alternatives discussed in Sections 8.2.1 and 8.2.3 in particular should be considered before the alternative discussed in Section 8.2.2 because of the relatively shorter paybacks. However, if in the future NYSDEC imposes more stringent air emission standards, then microturbines may become a better alternative for the City.

Section 9
FINAL RECOMMENDATIONS

9.1 SUMMARY OF EVALUATIONS

This report has identified additional alternatives to reduce energy usage at the Ithaca Area Wastewater Treatment Facility (IAWWTF). These alternatives include:

- Installation of automatic controls on the aeration system blowers.
- Conversion from ferrous chloride to ferric chloride use for phosphorus removal in the aeration basins.
- On-site generation facilities modifications.
- Replacement of the existing heating, ventilation, and air conditioning (HVAC) controls with an Energy Management System and Windows-based front end.
- Lighting improvements.

TABLE 9-1 summarizes the estimated energy savings, implementation costs, and simple payback periods for these alternatives.

9.2 SUMMARY OF RECOMMENDATIONS

Using the results of the evaluation summarized in TABLE 9-1, the following alternatives are recommended for implementation:

- Installation of automatic controls on the aeration system blowers.
- Replacement of the existing HVAC controls with an Energy Management System and Windows-based front end.

The remaining alternatives are not recommended due to long payback periods.

TABLE 9-2 contains a summary of the costs to implement the recommended alternatives only, as well as provides a summary of potential savings. The recommended alternatives offer a payback of 3.3 years, if implemented together, with a total annual savings of $26,700, which represents 8.1% of the IAWWTF's total annual energy costs ($328,259; based on 2002 and 2003 annual energy costs).

MALCOLM PIRNIE

New York State Energy and Research Development Authority
Municipal Wastewater Treatment Plant Energy Evaluation

Ithaca Area Wastewater Treatment Facility

Table 9-1 Summary of Energy Savings Alternatives Presented in Sections 5, 6, 7, and 8

ECM#	Measure Description	Non-Energy Related Benefits	Fuel Type Saved	Energy Saved (kWh)	Total Annual Dollars Saved*	Implementation Costs	Simple Payback Period (years)
1	Installation of automatic controls on the aeration system blowers.	Improved process control	electric	157,680	$14,700	$14,400	1.0
2	Conversion from ferrous chloride to ferric chloride use for phosphorus removal in the aeration basins.	n/a	electric	**	**	**	**
3	On-site generation facilities modifications: Alternative 1 - installation of gas storage facilities and new controls and continued operation of the existing co-generation units. Alternative 3 - installation of gas storage facilities and new controls and in-kind replacement of the co-generator units with higher efficiency reciprocating engines.	n/a	electric	Alternative 1 - 210,240 *** Alternative 3 - 525,600 ***	Alternative 1 - $29,114 Alternative 3 - $78,006	Alternative 1 - $173,500 Alternative 3 - $351,000	Alternative 1 - 6.0 Alternative 3 - 4.5
4	Replacement of the existing HVAC controls with an Energy Management System and Windows-based front end.	n/a	electric	168,336	$12,000	$75,000	6.3
5	Lighting improvements.	n/a	electric	108,000	$9,300	$81,000	8.7

* Dollars saved calculated by multiplying the energy saved by the rate of $0.093/kWh
** Alternative determined to be more costly (negligible electric energy savings and higher chemical costs) than existing operation; costs not developed.
*** Energy savings of on-site generation facilities measures expressed relative to savings of existing cogeneration facilities.

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Municipal Wastewater Treatment Plant Energy Evaluation

Ithaca Area Wastewater Treatment Facility

Table 9-2 Summary of Recommended Alternatives

ECM#	Measure Description	Non-Energy Related Benefits	Fuel Type Saved	Energy Saved (kWh)	Total Annual Dollars Saved*	Implementation Costs	Simple Payback Period (years)
1	Installation of automatic controls on the aeration system blowers.	Improved process control	electric	157,680	$14,700	$14,400	1.0
4	Replacement of the existing HVAC controls with an Energy Management System and Windows-based front end.	n/a	electric	168,336	$12,000	$75,000	6.3

* Dollars saved calculated by multiplying the energy saved by the rate of $0.093/kWh

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Ithaca Area Wastewater Treatment Facility

Table 9-2 Summary of Recommended Alternatives

ECM#	Measure Description	Non-Energy Related Benefits	Fuel Type Saved	Energy Saved (kWh)	Total Annual Dollars Saved*	Implementation Costs	Simple Payback Period (years)
1	Installation of automatic controls on the aeration system blowers.	Improved process control	electric	157,680	$14,700	$14,400	1.0
4	Replacement of the existing HVAC controls with an Energy Management System and Windows-based front end.	n/a	electric	168,336	$12,000	$75,000	6.3

* Dollars saved calculated by multiplying the energy saved by the rate of $0.093/kWh

As previously stated in Section 8, considering the condition of the existing co-generation units, no modifications to the on-site generation facilities are recommended at this time. However, when existing units approach the end of their useful lives, modifications should be considered. Both on-site generation facility Alternatives 1 (installation of gas storage facilities and new controls and continued operation of the existing co-generation units) and 3 (installation of gas storage facilities and new controls and in-kind replacement of the co-generator units with higher efficiency reciprocating engines) should be considered first because of their relatively short payback period. Alternative 2 (replacement of co-generator units with microturbines) should be considered in the future if the New York State Department of Environmental Conservation (NYSDEC) decides to impose more stringent air emission standards. Also as stated in Section 8, the IAWWTF should also consider involvement in a load curtailment program.