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Asset Management Plan Development for a Wastewater Treatment Plant

A Directed Project Report

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by

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ABSTRACT

This paper offers insight on the process utilized for developing a basic asset management and maintenance program for a series of assets at a wastewater treatment plant. The wastewater treatment plant where this project was conducted did not have an existing record of its assets nor did it have any type of substantial maintenance plan in place. This ultimately hindered the plant from prolonging the life of its assets and tracking any finances spent on their maintenance and repair. Throughout the duration of this project, asset information was obtained and an asset inventory was created. Operation and maintenance manuals, as well as other supplemental information for each of the assets identified, were obtained in order to develop a substantial maintenance plan for each of the assets. The conclusion of this project resulted in a current asset inventory and a proposed maintenance plan for each of the assets identified.

The project provided management at the wastewater treatment plant with a framework for the further development of their asset management plan as well as maintenance plans for any additions to their asset inventory in the future. This project provided a basic framework that allows management to continue to track maintenance and repair costs for the assets in their inventory if they choose to continue to do so.

During the course of this project, management of the plant requested that all identifying information is removed. Per management's request, all identifying information has been removed throughout this paper and all of the other deliverables that were involved in this project.

Keywords: asset management, asset maintenance, asset inventory, preventative maintenance, wastewater treatment plant, maintenance plan, reactive maintenance, corrective maintenance

INTRODUCTION

Asset management and maintenance is an inherent aspect of the basic operation and maintenance needs of any facility, regardless of the industry. Without an established asset management and maintenance plan in place, organizations risk underutilizing their existing assets, overspending on maintenance and repair costs, and significantly reducing the expected lifespan of their assets.

This project focused on the assets at a wastewater treatment plant in Indianapolis, Indiana that currently has a design flow of 7.5 million gallons per day (MGD). This wastewater treatment plant is responsible for collecting and processing wastewater from a number of towns in Indianapolis, Indiana. At the conclusion of the wastewater treatment process, this specific facility directs the fully treated wastewater into a public water source. The entire treatment process as a diagram can be viewed in Appendix A and the entire process is discussed later in this section.

Prior to this project, this specific wastewater treatment plant did not have an existing record of its assets nor did it have any type of maintenance plan in place. Consequently, the costs related to the maintenance and repair of the assets at the wastewater treatment plant were not carefully tracked nor were the costs actively allocated to specific assets. Due to time constraints, the project focused on the assets located within a specific area of the aforementioned wastewater treatment plant.

However, with that being said, a budget for maintenance and repairs is created each year by management at the wastewater treatment plant that is based on an average amount of finances spent on maintenance and repairs in prior years. This financial information was not shared by management at the plant during the project.

Wastewater Treatment Process

The wastewater treatment process begins at the head of the plant where the incoming wastewater from the city's sewer system is directed through the cylindrical fine screen. The cylindrical fine screen is used to remove all of the large materials and trash, such as cans and bottles, from the incoming wastewater. After the cylindrical fine screen, the wastewater is sent to a lift station, also referred to as a wet well, which by design, is used to move wastewater from a lower elevation to a higher elevation. The lift station pumps the water to the grit tanks. The grit tanks allow heavier materials such as sand and rocks to settle to the bottom of the tank. As these heavier materials settle, a grit separator is used to separate the water from this grit material. At this point, the grit separator sends the grit material to a dumpster where it is sent to a landfill. The water that was separated from the grit material is pumped back to the head of the plant to the primary settling tanks where it continues its treatment process.

The primary settling tanks are utilized to further separate the water from waste products within. These tanks allow lighter waste materials, which are now referred to as scum, to float on top of the water in the tanks. The remaining heavier waste materials, which are now referred to as sludge, settle to the bottom of the tanks. The floating material, or scum, is pumped to the head of the plant so that it can be removed by the cylindrical fine screen. The remaining sludge is then pumped to a thickening tank.

The thickening tank is used to further separate the water from the sludge, thus making the sludge thicker and reducing the amount of water that has to be completely removed from the sludge later in the wastewater treatment process. This is accomplished by vertical paddles that continuously circulate the water as it is being pumped into and out of the tank. The vertical paddles help with settling the sludge at the bottom of the tank and circulating the water so that it can be pumped away for further treatment.

At this point in the wastewater treatment process, there are now two items to treat, the sludge at the bottom of the thickening tank and the remaining water in the thickening tank. The sludge is pumped from the thickening tank to an anaerobic digester. The anaerobic digester is used to breakdown the organic matter in the sludge. This is accomplished by heating the digester to approximately 95 degrees Fahrenheit or 35 degrees Celsius. The sludge is held in the anaerobic digester at this temperature for at least 15 days.

After 15 days in the anaerobic chamber, the sludge is sent to the two belt filter presses where it is dewatered. The belt filter presses are relatively simple in regards to their operation. First, the sludge is run across a porous belt that allows free water to drain from the sludge with the help of gravity. Then, the sludge is sandwiched between two belts to remove the remaining water from the sludge. The dewatered sludge is moved by a hopper to a storage building. This dewatered sludge, which is primarily dried, is transported to various farms to be utilized as fertilizer and soil conditioner. The water that was squeezed out from the sludge by the belt filter presses is pumped to the head of the plant so that it can be processed.

The water that was removed from the sludge in the thickening tank must now be processed. From the thickening tank, the remaining water is pumped to the Unox tank. In the Unox tank, the wastewater is treated further through the utilization of microorganisms that feed on the organic waste materials in the water. In order to promote their feeding and growth, the water is aerated with oxygen through the use of a pressure swing adsorption (PSA) unit. To put it simply, the PSA unit takes air from the atmosphere and separates the oxygen and nitrogen gases. The PSA unit discharges the nitrogen back to the atmosphere and the oxygen is sent to the Unox tank for aerating the wastewater for the microorganisms. Following treatment in the Unox tank, the water is pumped to the final settling tanks.

The final settling tanks are used to allow any of the microorganisms or any remaining material in the water to settle to the bottom. This allows a clear liquid to remain at the top of the settling tanks. The clear liquid is pumped to the nitrification towers and the contents that settled at the bottom of the final settling tanks are pumped back to the Unox tank.

The nitrification towers are utilized to remove ammonia from the water. This is accomplished by the internal components of the towers. In each of the towers, there is a plastic surface that is utilized to grow a specific strain of bacteria, which feeds on the ammonia in the water. The incoming wastewater is distributed across the surface that houses the bacteria. As the wastewater moves across this surface and the bacteria, the bacteria convert the ammonia in the water to nitrates.

After the nitrification towers, the water is pumped to the ultraviolet (UV) system where the water is disinfected using a specific ultraviolet wavelength. The water is pumped through a channel that contains eight banks of UV light bulbs. Each bank holds 40 bulbs. As the water passes by the UV bulbs, the UV light that is emitted kills any living pathogenic bacteria that are in the wastewater. Once the water is treated by the UV system, it is discharged into a public water source.

PROBLEM STATEMENT

Prior to this project, this facility did not have an asset inventory record. Nor has this facility ever utilized a maintenance plan for its assets. The maintenance tasks that were conducted at this facility were either corrective or reactive in nature.

Due to the nature of the existing maintenance procedures for this facility, or lack thereof, it was highly likely that there was a substantial amount of unforeseen and potentially unnecessary repair and replacement costs that could have been significantly reduced or even avoided altogether if a maintenance plan were previously developed and implemented at the facility.

SIGNIFICANCE

Proper asset management and maintenance are vital to the overall success of an organization. As Walker outlines "asset management is at the core of any organization's success. If handled well, it contributes to the overall productivity and efficiency. As a result of which the organization is able to save a lot of money on multiple levels" (Walker, 2017). Without proper asset management and maintenance procedures in place, organizations risk spending their precious financial resources on multiple repairs and even the premature replacement of equipment that could have been avoided had a suitable plan been in place. With a suitable maintenance plan implemented, financial resources can be allocated to other areas of need in the organization because the life expectancy of the assets and the amount of time between failures is likely to increase with regular maintenance intervals.

One prime example that was obtained throughout the duration of this project refers to the finances spent on the maintenance and repair of a boiler over the past seven years that was originally installed at the facility in 2006. Management indicated that they have been tracking the maintenance and repair costs, starting in 2012, on this specific boiler in an attempt to obtain approval for the purchase and installation of a replacement boiler. At the conclusion of this project, management at the plant was still working on obtaining approval for the boiler's replacement. The maintenance and repair costs for this specific boiler over the past seven years are as follows:

Year	**Maintenance and Repair Costs**
2012	$25,301
2013	$11,121
2014	$23,365
2015	$5,762
2016	$3,010
2017	$1,304
2018	$8,906
June-19	$15,333
Total Maintenance and Repair Costs for Boiler	**$94,102**

Based on this financial data, replacing the boiler may be ideal and the better option at this point when considering the total amount that has already been spent on the existing boiler's maintenance and repair over the past seven years alone. Although data was not available for the cost of repairs and maintenance on this specific boiler prior to the past seven years, it is likely that the boiler could have been replaced well before the facility began tracking maintenance and repair costs seven years ago.

LITERATURE REVIEW

The purpose of this project was to develop a current asset inventory as well as develop and propose a maintenance plan for the current assets at this water treatment facility in an attempt to prevent and reduce future unplanned maintenance tasks, improve the facility's asset tracking and cost control measures, reduce their operating and maintenance costs over time, and to maximize the useful life of the existing systems and equipment within the building.

Prior to the project, the building at this treatment plant did not have a current asset inventory that allowed management to track and allocate costs for individual assets when the assets required maintenance, repair, or even replacement. There was no maintenance plan in place at this facility and all maintenance tasks were either corrective or reactive.

In 2015, Asset management was defined in the International Infrastructure Management Manual (IIMM) as "the combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost-effective manner" (NEWEA, 2019).

In his report, Wright clearly outlines that asset management, as a whole, "is a huge, important and growing industry that plays a vital economic and societal role in managing risk and return for its customers and allocating capital" (Wright, 2018).

Asset management, regardless of the industry in which it is applied, is crucial for decision making, especially when it relates to operations and maintenance. Asset management helps companies with identifying their actual organizational needs because they are able to gain a better understanding of their maintenance, repair, and replacement needs as they develop, implement, and maintain an asset management program (The United States General Accounting Office, 2004). As expected, asset management also aids management with justification and planning for future investments and equipment replacements as they are needed. An asset management program that is successfully implemented and regularly updated helps to ensure that companies are in compliance with the regulations and standards that are set by the multitude of agencies that govern the various industries. Water treatment facilities have a large number of regulations and standards in which they must adhere to in order to ensure the quality of the water that leaves their facility. Asset management is one tool that these facilities can utilize to assist with their compliance with regulatory agencies and to ensure that the water that leaves their facility is of the highest quality.

Purpose of Asset Management in Water Treatment Facilities

The United States Environmental Protection Agency (EPA) mentions that "many utilities struggle to operate, maintain, and improve systems and infrastructure assets installed decades ago. Uncertainty about the location and condition of infrastructure assets and lack of comprehensive planning often leads to a reactive approach to maintenance and the occurrence of emergency situations stemming from asset failures" (The United States Environmental Protection Agency, 2017). The EPA also mentions that in order, "to battle this tendency, utilities (particularly wastewater and drinking water utilities) have developed and implemented formal asset management programs (AMPs) to reduce unexpected, expensive, and reactive repairs and increase overall system performance" (The United States Environmental Protection Agency, 2017).

Renner outlines that, "the life of any treatment plant, pumping station, or other water or wastewater system structure is determined in part by such factors as the materials of construction, the design engineer, the contract specifications, and the facility's location and cost. But the major contributor to an effective life span is more often than not a well-developed and implemented maintenance program that keeps equipment running and buildings and structures sound" (Renner, 2000).

To put it simply, a good asset management and maintenance program will extend the equipment life and reduce the number of breakdowns that are experienced. This program will help to reduce the maintenance costs of the facility, which can be seen over time. Asset management is an effective tool that water treatment facilities can choose to utilize in order to assist with maintaining their assets and the associated operating and repair costs effectively, maintaining their compliance with regulatory agencies, and ensuring that the water leaving their facilities is of the highest quality.

The United States Environmental Protection Agency (EPA) defines asset management for water and wastewater utilities as, "a process water and wastewater utilities can use to makes sure that planned maintenance can be conducted and capital assets (pumps, motors, pipes, etc.) can be repaired, replaced, or upgraded on time and that there is enough money to pay for it" (The United States Environmental Protection Agency, 2018). The EPA outlines that asset management, "is the practice of managing infrastructure capital assets to minimize the total cost of owning and operating these assets while delivering the desired service levels" (The United States Environmental Protection Agency, 2018).

Also, according to Alegre and Coelho, asset management of urban water systems is necessary, "in order to ensure that [the water system's] performance corresponds to service targets over time, that risks are adequately managed, and that the corresponding costs, in a lifetime cost perspective, are as low as possible" (Alegre & Coelho, 2012). Throughout their writing, they cover various purposes and needs for an accurate and up-to-date asset management program in water treatment facilities. They outline utilizing asset management to assist with managing risks while taking into account users' needs, adjusting the systems to withstand climate and environmental changes , extending the service life of existing assets instead of replacing them, if at all possible, and improving investment and operational efficiency within the organization, just to name a few.

In addition to the maintenance and cost-saving benefits of an asset management program, "when wastewater treatment systems are properly designed, constructed, and maintained, they effectively reduce or eliminate most human health or environmental threats posed by pollutants in household water. However, they require regular maintenance or they can fail. Systems need to be monitored to ensure that they work properly throughout their service lives" (Alberta Onsite Water Management Association, 2019).

Potential Barriers to Development and Implementation

As with any major change or implementation, there is always a concern as to whether the change will make a significant difference, what problems or issues it may bring, and what the change is going to cost the company. This process can also seem overwhelming, especially to those facilities that are conducting this process for the first time. In his article, *Maintaining Wastewater Treatment Plant Infrastructure*, Vidor outlined one of the major challenges, of many, that often arise when asset management and maintenance programs are discussed. In his article, he mentions that, "With repair dollars for municipalities in short supply and service life expectancy rising, structural preservation and safety become top priorities for public works organizations" (Vidor, 2008).

In addition to cost and the need for the equipment to last longer, there are many other barriers that may occur, which could hinder the overall success of the asset management plan implementation process. Other barriers involve being able to effectively communicate with stakeholders in order to show them the importance and significance of an asset management program, incorporating a newly-developed program with existing programs or data management systems, if applicable, and assuring those involved that the decades of deferred maintenance or neglect that may be apparent do not always need to be rapidly addressed when the asset management plan is implemented (The United States Environmental Protection Agency, 2017).

Asset management assists companies, regardless of their industry, with identifying their actual organizational needs because they are able to gain a better understanding of their maintenance, repair, and replacement needs as they develop, implement, and maintain an asset management program.

Based on the data collected, it is evident that developing and implementing an asset management plan at this or facility can be beneficial in a multitude of ways, even though there could be some barriers that may arise.

PURPOSE

The intent of this project was to successfully develop both an asset management plan and a maintenance plan for a series of equipment at a wastewater treatment plant. Prior to this project, the wastewater treatment plant did not have an asset inventory or a maintenance plan in place. The absence of an asset inventory at this facility prevented management from being able to track and allocate costs for individual assets when the assets required maintenance or repair. The lack of basic cost control or tracking measures also prevented management from having a solid understanding of the maintenance, repair, and replacement needs of the equipment at the wastewater treatment plant.

DEFINITIONS

Activated sludge – A wastewater treatment process for treating sewage that involves aerating the sewage and promoting the growth of microorganisms that help to break it down.

Anaerobic – A process that requires or involves the absence of oxygen.

CM – Corrective Maintenance: A type of maintenance that involves "repair actions [that are] initiated as a result of observed or measured conditions of an asset after or before the functional failure" (Gulati, 2013, p. 52).

CMMS – Computerized Maintenance Management System: Computer software developed and sold by multiple vendors that are used to simplify the management of maintenance operations.

Effluent (Water) – "Liquid waste or sewage discharged into a river or the sea" (Lexico.com, 2019).

EPA – The United States Environmental Protection Agency: An independent agency of the United States federal government that is dedicated to the protection of human health and the environment (The United States Environmental Protection Agency, 2018).

Maintenance Interval – Predetermined points in time in which specific maintenance tasks may be suggested or required by the original equipment manufacturer to be performed on an asset in order to prolong its lifespan and maintain its operating capacity.

MGD – Million Gallons per Day

OEM – Original Equipment Manufacturer: A company that manufactures or develops a component, a piece of equipment, a system, or another type of product that is eventually sold to another company that sells and distributes the product as its own.

P&ID – Piping and instrumentation diagram

PM – Preventative Maintenance: A type of maintenance that involves a series of actions that are performed on an asset on a specific schedule. The main goal of preventative maintenance is to minimize asset degradation in order to sustain or extend the useful life of the asset (Gulati, 2013, p. 53).

RM – Reactive Maintenance: “[A type of] maintenance repair work done as an immediate response to an asset failure, normally without planning and unscheduled” (Gulati, 2013, p.53).

Sewage sludge – “The solid, semisolid, or slurry residual material that is produced as a by-product of wastewater treatment processes” (Encyclopædia Britannica, Inc., 2019).

WWTP – Wastewater Treatment Plant: A facility that utilizes various processes to remove contaminants from wastewater, eventually changing the water into a state so that it can safely be returned to the environment with minimal impact.

SNDR – Storage Nitrification Denitrification Reactor

UV – Ultra-Violet

ASSUMPTIONS

The project that was completed assumed the following conditions:

1. If the operator's manual or the maintenance manuals were not available on site for the equipment, additional research was conducted in order to either obtain the appropriate manuals for the equipment or to create an adequate maintenance plan that can be implemented for the equipment instead.
2. Any building assets or equipment that could not be accurately dated for the asset inventory portion of the project were presumed to be manufactured on January 1, 2000.

DELIMITATIONS

The purpose of this project was to develop an asset management plan which involved the development of a current asset inventory and a proposed maintenance plan for each of the assets identified in the inventory.

The assets included in the project were limited due to the time constraints for this project. The assets and/or equipment involved in the project did not include the systems connected to the individual assets and/or equipment, such as the electrical wiring, electrical components, or plumbing that the equipment either utilizes to run or that the equipment is being employed to handle. For the sake of this project and its resource constraints, these systems were considered as a different classification of assets that, in this case, fall under a separate, yet similar type of maintenance plan, if it exists, which is outside the scope of this project.

Due to the cost and time constraints of this project, evaluation and disclosure of the long-term effects of the asset management plan's implementation at the wastewater treatment plant were not included in the scope of this project.

METHODOLOGY

This project was completed in four major phases that included multiple tasks that needed to be accomplished. Each phase was one week or seven days long. During the first phase, two visits to the wastewater treatment plant were scheduled in order to collect as many identification details for each of the assets included in the project as well as to collect any information that was missed on the initial visit. Details such as the asset's manufacturer, manufacture date, model number, and serial number were collected from each of the assets. Following the two visits to the wastewater treatment plant, the asset details were compiled and an asset inventory list was created in Microsoft Excel, which can be viewed in Appendix B. Piping and instrumentation diagrams were requested during this phase, but they could not be provided as they were either outdated or non-existent.

During the second phase, the details collected previously were utilized to research each of the assets in an attempt to locate any related manuals or other pertinent resources that might have listed maintenance-related details such as maintenance procedures, maintenance intervals, maintenance parts, part replacement needs or requirements, or any other details that could be utilized to effectively maintain the asset and ultimately prolong its lifespan. This phase consisted of organizing the maintenance details and information found by asset as well as by maintenance interval, if applicable to the asset.

The third phase of this project involved developing a maintenance plan for each asset in the recently developed asset inventory based on the maintenance information obtained through research in the previous phase. The maintenance information obtained for each of the assets was organized through the utilization of Microsoft Excel. This phase also involved presenting the recently developed asset inventory and maintenance plan to management at the wastewater treatment plant for feedback. Any adjustments that were suggested by management were made during this phase as well.

The fourth and final phase involved finalizing the asset inventory and maintenance plan based on the feedback and adjustment requests received from management at the plant in the previous phase. This phase also included the presentation of the finalized asset inventory and maintenance plan to management at the wastewater treatment plant for their further utilization, if they choose to do so. At the conclusion of this project, management had yet to determine whether they were going to continue the development of the asset inventory and proposed maintenance plan.

RESULTS

This project in its entirety was successful. An asset inventory, as well as a maintenance plan for each of the assets identified, were developed and presented successfully to management at the wastewater treatment plant. Throughout the duration of the project, it became apparent rather quickly that some of the equipment at the plant holds a higher priority and have a larger impact in the regular operations of the plant if they fail. For this reason, the majority of these higher-priority assets were identified in this project and maintenance plans were developed.

It was difficult to find maintenance information and manuals for some of the older assets identified. Some of the assets identified did not have any manufacturer recommendations for maintenance, which was often dependent on the age of the asset. Also, some of the manufacturers explicitly state that there is no routine maintenance required for their equipment.

Although there is still the possibility that the work completed throughout this project may not be utilized by management at the treatment plant, this project did help to educate management and staff at the wastewater treatment plant. This project educated both the management and staff on how to further develop their asset inventory as well as how to develop, implement, and utilize a maintenance plan. This project helped to outline the benefits of utilizing an asset inventory and a maintenance plan for tracking costs associated with the maintenance and repair of assets at the plant. This project also showed how tracking costs could be utilized for annual budgeting purposes as opposed to their existing methods which are based on an average amount spent on maintenance and repair over a series of previous years.

LIMITATIONS

There were multiple limitations identified prior to the start of this project as well as throughout the duration of the project. One limitation identified prior to the start of this project was the time constraint, as it prevented any post-implementation evaluations of the potential benefits, cost-related and otherwise, that could have been or were experienced by the wastewater treatment plant. The time constraints surrounding this project prevented its further development and hindered the overall benefit to the wastewater treatment plant.

A second limitation that was identified prior to the project was the possibility that maintenance manuals for the equipment may not be available onsite or they may not be able to be located through alternate research methods. This limitation was experienced with some of the assets identified during the project. For this reason, some of the manufacturer-specific maintenance recommendations were not available for some of the assets identified.

Another limitation that was identified prior to the project as well as during the project was the size of the maintenance team. The size of the maintenance team for the size of the facility and the multitude of assets and equipment that they are responsible for repairing and maintaining is not adequate, especially when considering the additional maintenance requirements for each of the assets identified during the project. At the conclusion of the project, the facility only had two full-time maintenance technicians.

As mentioned previously, there were some additional limitations that were identified throughout this project. One of the limitations that were identified during this project was that some of the assets did not have any identifying information on them as the information was either corroded so it could not be read, the metal, stamped plates were missing, if applicable, or the information had been painted over. This made it difficult to identify the assets as well as to obtain any manuals or manufacturer-related information for further research.

A second limitation that arose during the course of the project was that there were no piping and instrumentation diagrams that could be provided for utilization. The diagrams were either outdated or non-existent, which was dependent on the equipment being analyzed and the location of the equipment.

A final limitation that was identified was in regards to the age of the plant and the assets that were relatively close in age. These older assets caused some difficulties when researching for manuals, maintenance details, maintenance intervals, and other pertinent information. Although this limitation was expected at the start of this project, it was assumed that the information could be found through alternative research methods. Unfortunately, it became apparent that this information was very difficult to find, if possible, even when utilizing alternate research methods.

CONCLUSION

A quality asset management and maintenance program is a crucial part of the basic operation and maintenance needs of any facility, regardless of the industry. Without an established asset management and maintenance plan in place, organizations risk underutilizing their existing assets, overspending on maintenance and repair costs, and significantly reducing the expected lifespan of their assets. This project developed a partial asset inventory and an accompanying maintenance plan for those assets that were outlined in the inventory.

It is recommended that the wastewater treatment plant further develop the asset inventory as well as the maintenance plan as assets are added to its existing inventory. It would be beneficial for the wastewater treatment plant to eventually purchase and utilize a computerized maintenance management system. Purchasing a CMMS would assist the plant with managing their assets, allocating costs for repairs and maintenance, budgeting for future repair, maintenance, and replacement needs, and managing the maintenance and repair of the assets at the facility.

If they are available, it is also recommended that the wastewater treatment plant obtain, store, and utilize operation and maintenance manuals for all of the equipment being utilized at the facility. This information should continue to be used throughout the life of the equipment. Manuals should be obtained and utilized for all equipment that is purchased and installed in the future as well.

In addition to the manuals for the equipment, it would be beneficial for the wastewater treatment plant to have a current process flow diagram created that includes all of their current equipment that is being utilized at the plant. It would also be beneficial for current plumbing, instrumentation, and electrical diagrams to be created as well. At a minimum, these diagrams have the potential to assist maintenance personnel or contractors with locating various components that may be relevant for certain maintenance procedures, troubleshooting, and future planning and projects.

Although there were multiple difficulties experienced throughout the duration of this project, the project was an overall success as it provided a basic framework for the facility to continue to build from. This project also provided an educational and eye-opening experience for multiple members of the staff at the wastewater treatment plant.

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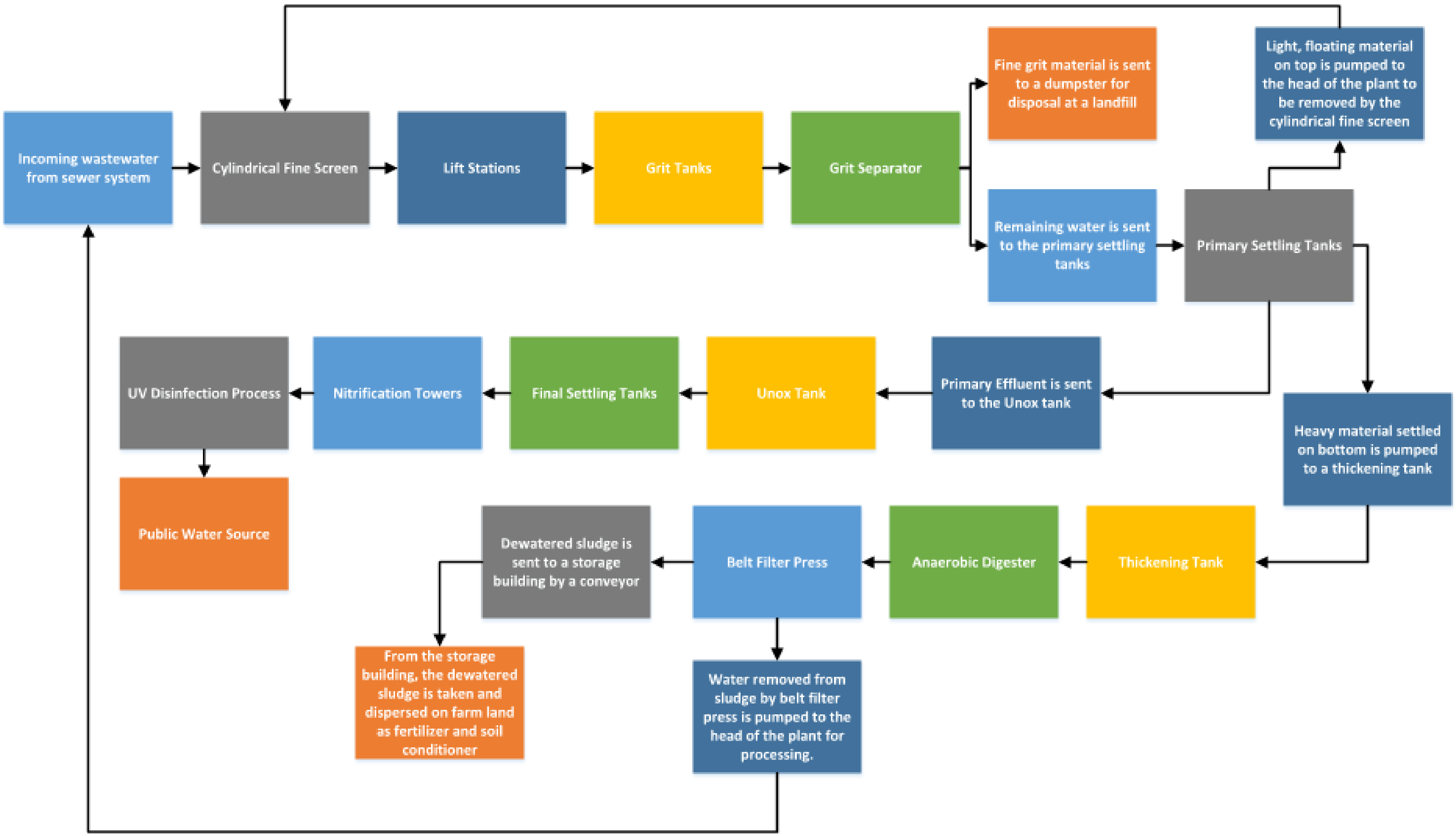
APPENDIX A

WASTEWATER PROCESS FLOW MAP



APPENDIX B

PROJECT ASSET INVENTORY LIST

Wastewater Treatment Plant Project Asset Inventory As of June 2019						
	Asset #	**Serial # (if applicable)**	**Manufacturer**	**Model (if applicable)**	**Asset Description**	**Date of Manufacture or Installation Date**
1	000001	LAK1563	Lakeside Equipment Corporation	Raptor	Cylindrical Fine Screen	May 2000
2	000002	SPE072815.1.1	Headworks International	MS1	Vertical Bar Screen	July 2015
3	000003	1800-02-0228	Ozonia North America (Now Suez Water Technologies)	Aquaray 40HO	Ultraviolet Disinfection System	December 2011
4	000004	UN-942	Komline-Sanderson	G-GRSL-2 Series 3	Belt Filter Press (#1)	January 2000*
5	000005	UN-943	Komline-Sanderson	G-GRSL-2 Series 3	Belt Filter Press (#2)	January 2000*
6	000006	P00460	Walker Process Equipment		Dual-Fuel Boiler	January 2006
7	000007	110113.1	Penn Valley Pump	6DDSX76	Double Disc (Sludge) Pump	January 2011
8	000008	110114.1	Penn Valley Pump	6DDSX77	Double Disc (Sludge) Pump	January 2011
9	000009					
10	000010					

APPENDIX C

PROPOSED MAINTENANCE PLAN

	Equipment	Frequency	Component / Task
1	**Cylindrical Fine Screen (Lakeside Equipment Corporation)**		
		5 years or 20,000 hours, whichever comes first	Cyclo / Complete overhaul
		Semi-annually	Helical / Oil change
		6 months or 500 hours, whichever comes first	Lower bearing / Check for excessive wear and replace if necessary
		Every two weeks	Wash water strainer / Rinse strainer and replace if necessary
2	**Vertical Bar Screen (Headworks International)**		
		Weekly	Inspect screen field for debris or build up. Remove debris manually if necessary.
		Semi-annually	Inspect conveyor chain.
		Semi-annually	Oil conveyor chain
		Semi-annually	Inspect scraper blade. Readjust and replace as necessary.
		Annually	Inspect channel side seals. Replace as necessary.
		Annually	Perform motor checks. Verify amperage.

PROPOSED MAINTENANCE PLAN

	Equipment	Frequency	Component / Task
3	Aquaray 40HO Ultraviolet System (Ozonia North America)		
		As needed	Replace quartz jackets.
		As needed	Replace ballasts
		As needed.	Replace bulbs Note: Bulbs not to exceed 13,000 operating hours.
		Daily	Check effluent level to ensure that it is between 57.5" and 62" for each module/bank.
		Daily	Visually inspect modules to ensure no abnormal conditions are present.
		Daily	
		Weekly	Module (bank) cooling fans / Clean fan grill and remove debris.
		Weekly	Channel / Check for build up of solids, algae, or other forms of debris. Clear and clean debris as needed.
		Monthly	Clean modules. Inspect quartz jackets for damage.
		Monthly	Inspect module seals and gaskets for wear. Replace if necessary.
		Monthly	Inspect module lid latches. Ensure that the latches properly seal.
		Monthly	Inspect power and data connections to the modules. Ensure seals are intact and free of damage. Ensure wiring is not frayed or damaged.

PROPOSED MAINTENANCE PLAN

	Equipment	Frequency	Component / Task
4	**Belt Filter Press #1, #2 (Komline-Sanderson)**		
		As needed	Replace tracking sensors
		Weekly	Grease drum bearings
		Weekly	Lubricate roller bearings
		Weekly	Lubricate alignment shafts
		Weekly	Lubricate drive gears
		Monthly	Inspect roll and drum alignment, set screws, and fasteners
		Monthly	Clean belt wash spray nozzles
		Monthly	Check oil quality and level in the main drive gear reducer. Replace if needed.
		Monthly	Clean belt tracking sensors. Clean or grease if needed
		Semi-Annually	Lubricate pressure belt motor bearings
		Semi-Annually	Check wedge zone side seals for excessive wear. Replace if needed.
		Semi-Annually	Check discharge scraping blades for wear. Replace if needed.
		Semi-Annually	Check gravity side seals, feed distribution box seals, and washbox seals. Replace defective or worn seals as needed.
		Semi-Annually	Wash and inspect filter belts. Replace if issue or defect is found.
		Semi-Annually	Check plows for wear and sharp edges. Replace if needed.
		Semi-Annually	Check washwater spray nozzle spray pattern. Replace defective nozzles as needed.
		Semi-Annually	Replace moisture inhibitor for the main control panel.
		Annually	Replace filter belts.
		Annually	Change drive oil.
		Bi-Annually	Change oil in pressure belt reducer.
		Every 5 years	Regrease main drive motor.

PROPOSED MAINTENANCE PLAN

	Equipment	Frequency	Component / Task
5	**Dual-Fuel Boiler (Walker Process Equipment)**		*No maintenance information located. Alternative information utilized.
		Daily	Verify vents and/or flues are not obstructed. (Debris, ice, snow, etc.) Clear obstructions if found.
		Weekly	Check temperature and pressure readings and ensure they are within operating range.
		Monthly	Inspect boiler for 'hot spots.'
		Monthly	Check hydronic piping for leaks.
		Quarterly	Clean and inspect heat exchanger. Clean fire tubes.
		Quarterly	Inspect and clean flame sensors, ignitors, and burners. Replace as necessary.
		Quarterly	Inspect insulation materials for damage or wear. Replace as necessary.
		Quarterly	Inspect supply valves for proper operation. Replace if defective.
		Quarterly	Check safety valves for proper operation. Replace if defective.
		Quarterly	Check gas valves for proper operation. Replace if defective.
		Quarterly	Check all connections to and from boiler for leaks or damage.
		Semi-Annual	Check all electrical wiring and connections for any wear, corrosion, or damage. Replace as necessary.
		Annual	Maintenance visit and operation verification by qualified technician.
6	**Double Disc Sludge Pump #1, #2 (Penn Valley Pump Co.)**		*No routine maintenance required by manufacturer, Penn Valley Pump Company, Inc.
		Semi-Annually	Inspect pump connections for leaks.
		Semi-Annually	Inspect belts for wear. Replace as necessary.
		Semi-Annually	Inspect suction disks for wear or damage. Replace as necessary.