Hillsdale Board of Public Utilities, Hillsdale County
Summary of Components Qualifying for Green Project Reserve
May 2014

Summary

The last significant improvements project at the Hillsdale wastewater treatment plant (WWTP) was in 1992. The 1992 project converted the trickling filters to oxidation ditches and added a circular secondary clarifier to the north of the north oxidation ditch. Return activated sludge (RAS) structures and equipment were also added along with a new tertiary filter pumping building and miscellaneous process equipment and controls. The primary and south secondary clarifiers were upgraded utilizing concrete structures that were originally installed in 1947; the concrete is now deteriorated to the point where economical repair is not possible. The clarifier building is of the same vintage and is beyond repair. In addition, the traveling bridge sand filters and anaerobic digester equipment, installed in 1980, have reached the end of their useful life. The proposed SRF project will equip the plant to operate successfully for the next 20 years.

The Recommended Alternative incorporates several Green Project Reserve (GPR) components that will provide environmental benefits beyond those typically achieved at wastewater treatment facilities. The Recommended Alternative is in keeping with the City's commitment to provide continued reliable wastewater service while pursuing innovative, environmentally attractive, and cost effective technologies. The City and Board of Public Utilities (BPU) embrace environmental Best Management Practices that surpass ordinary utility practices and further the goals of the Clean Water Act.

The total pre-design budgetary estimate of probable costs for the GPR eligible components is $5,334,000 including non-construction costs. Refer to the attached cost estimate for a breakdown of the GPR components.

Background

The Hillsdale WWTP serves the City of Hillsdale, including Hillsdale College. The plant has a rated capacity of 2.0 mgd. Currently, the WWTP includes screening/grinding, grit removal, primary clarification, oxidation ditch aeration, secondary clarification, chlorination and dechlorination. Solids processing includes gravity thickening and anaerobic digestion followed by storage in the sludge storage tanks.

Proposed improvements include new influent pumps, upgrades to the headworks facilities, minor rehabilitation at the oxidation ditches, new south secondary clarifier, improvements to the RAS/WAS system, replacing the tertiary filtration system, anaerobic digestion system upgrades, SCADA upgrades, building insulation, and miscellaneous improvements.

GPR Classification

The anaerobic digestion portion of the project qualifies for GPR funding under 3.2-2 Energy Efficient Categorical Projects that result in a 20% energy savings.

The biogas combined heat and power (CHP) system qualifies under 3.2-1 Energy Efficient Renewable Energy Categorical project.

The building insulation project qualifies under 3.2-2 Energy Efficient Categorical Projects that result in a 20% energy savings.

Replacement of the traveling bridge sand filters with disc filters qualifies under 2.4-2 and 2.4-3 water efficiency business case based on a reduction in backwash water.

Installation of VFDs on the oxidation ditch aerators qualifies under 3.2-2 Energy Efficient Categorical Projects that result in a 20% energy savings.

Confirmation

Anaerobic Digester

The WWTP's anaerobic digester is currently heated with purchased natural gas, averaging approximately 1400 ccf/month natural gas use. The proposed high-rate digester upgrades will generate biogas at a rate of 2740 ccf/month as methane. Accordingly, biogas will satisfy the digester heating requirement, virtually eliminating the need for natural gas to heat the digester. In order to accomplish the anticipated 2740 ccf/month biogas methane production rate, several improvements to the existing digester system are needed to convert it to a high-rate system.

The existing headworks processes include a sewage grinder and a grit removal system. The existing grit removal system retains organic rich solids, preventing the material from utilization as a source of volatile solids to feed the digester. Stringy, fibrous materials shredded in the grinder currently agglomerate in the anaerobic digester, causing clogging and "ragging" of equipment, reducing the ability of the anaerobic digester mixing and heating systems to maintain efficient operation. Biogas production is adversely impacted by poor digester mixing and heating and could even result in the need for supplemental natural gas for digester heating. This was the case demonstrated at the Sturgis, Michigan WWTP as part of their Green Project Reserve application.

Screening and organics washing is proposed to mitigate the ragging problems and to increase gas production in the anaerobic digestion process. Screening will remove materials from the flow stream rather than passing them to the downstream processes. The screen will mitigate the potential for stringy materials to agglomerate in the digester pipes, valves and heat exchanger, allowing for more efficient and continuous operation. In addition, the rehabilitated grit removal equipment will be designed to wash more organics from the grit, providing additional volatile solids for the production of biogas in the digester.

The organic solids recovery tank harvests volatile solids-rich "food" for the anaerobic digester. The benefits of the organic solids tank are two-fold: 1) it increases the VS content in the sludge sent to the digester, and 2) it reduces the aeration requirement in the oxidation ditches.

When the organic solids recovery tank is bypassed (i.e. for maintenance) the organics are sent to the oxidation ditch where activated sludge converts it to biomass. The anticipated biogas production rate from digesting only biomass is 1075 ccf/mo as methane, providing a 77% reduction in natural gas consumption. During normal operation with the solids recovery tank in operation, the anticipated biogas production rate from digesting biomass plus organic solids is 2740 ccf/mo as methane, thereby allowing a nearly 100% reduction in natural gas energy.

As previously stated, when the organic solids recovery tank is bypassed the organics are sent to the oxidation ditch where activated sludge converts it to biomass. The conversion requires oxygen and the aeration equipment draws 28 hp while turning 55 rpm at this loading condition. During normal operation with the solids recovery tank in operation, significantly less oxygen is needed satisfy the biomass. Slowing the rotational speed of the aeration equipment to 43 rpm in order to transfer an appropriate amount of oxygen to the oxidation ditch has the additional benefit of drawing only 15 hp of power, a 46% reduction in electrical energy.

The anaerobic digester rehabilitation alone will reduce natural gas purchases for digester heating by 75%. The organic solids recovery tank will enable an almost complete elimination of natural gas purchases and a 46% energy savings on the oxidation ditch aeration equipment operation. Both the anaerobic digester and organic solids recovery tank parts of the project have energy savings in excess of 20%, therefore they qualify under 3.2-2 Energy Efficient Categorical Projects.

Combined Heat and Power

The combined heat and power (CHP) portion of the Recommended Alternative includes an electric generator configured to operate on biogas, a biogas compression skid, and piping to deliver biogas to the CHP unit. The electricity from the generator will be utilized on site with a possible connection to the grid provided by the BPU. Heat from the generator motor will be captured and used to heat the digester and the digester building. The digester boiler will serve as the standby heat source for times when the generator is out-of-service for maintenance.

CHP components qualify for GPR funding under Section 3.2 - Categorical renewable energy projects. The CHP equipment will be designed to utilize biogas to provide power to the publically owned treatment works (POTW).

Building Insulation

Most of the buildings at the plant were designed and constructed in the early 1980s without much consideration for energy efficiency. Since energy costs have risen since that time, the amount of insulation typically used in new construction has increased. In 2010 the State of Michigan adopted the Michigan Uniform Energy Code which provides guidance on the amount of insulation recommended for commercial buildings. The current recommendation for roof insulation is an R-value of 15 and for walls, 11.4. The existing WWTP buildings have significantly less insulation than the current standards recommend.

The R-value is a measure of thermal resistance used in the building industry. A 20% increase in the R-value results in a 20% decrease in energy lost to the environment. Following current recommendations, the proposed R-value increases are significantly greater than 20%.

The total R-value for a roof or wall system is calculated by adding the R-values for all the components. For the Main and Headworks buildings, the existing wall construction consists of exterior brick, interior block and 1 inch of rigid insulation between the wythes. The existing roof construction is precast concrete plank with a lightweight concrete insulating topping under a ballasted membrane. The R-values are calculated as follows:

Table 1 - Roof "R" Value for Main and Headworks Buildings

Item	Existing	Proposed
Outside air	0.17	0.17
Membrane	0.00	0.00
Insulation		19.00
Lt. Wt. concrete	1.00	1.00
Vapor Barrier	0.00	0.00
2" concrete tee	1.00	1.00
Inside air	0.61	0.61
Total R	2.78	21.78
Energy reduction= (21.78-2.78)/2.78 x 100 = 680%		

Table 2 - Wall "R" Value for Main and Headworks Buildings

Item	Existing	Proposed
Outside air	0.17	0.17
Cladding		0.00
Insulation		7.50
4" brick	0.40	0.40
Air space	0.91	0.91
Insulation	4.00	4.00
CMU	4.50	4.50
Inside air	0.61	0.61
Total R	10.59	18.09
Energy reduction= (18.09-10.59)/10.59 x 100 = 70%		

For the tertiary building, the existing wall construction consists of exterior brick, interior block and 1-1/2 inch of rigid insulation between the wythes. The existing roof construction is precast concrete plank with 2 inch rigid taped insulation under a built-up roofing system. The R-values are calculated as follows:

Table 3 - Roof "R" Value for the Tertiary Building

Item	Existing	Proposed
Outside air	0.17	0.17
Membrane	0.00	0.00
Insulation	8.00	18.50
8" precast plank	4.00	4.00
Inside air	0.61	0.61
Total R	12.78	23.28
Energy reduction= (23.28-12.78)/12.78 x 100 = 82%		

Table 4 - Wall "R" Value for Tertiary Building

Item	Existing	Proposed
Outside air	0.17	0.17
Cladding		0.00
Insulation		7.50
4" brick	0.40	0.40
Air space	0.91	0.91
Insulation	6.00	6.00
CMU	4.50	4.50
Inside air	0.61	0.61
Total R	12.59	20.09
Energy reduction= (20.09-12.59)/12.59 x 100 = 59%		

Both the wall and roof insulation R-values will be increased by greater than 20% for all three buildings, so the components qualify under 3.2-2 Energy Efficient Categorical Projects.

Disc Filter

The existing tertiary filters are operating beyond their useful life, in need of significant rehabilitation or replacement. They have experienced a dramatic decrease in hydraulic capacity over the years. The reduced hydraulic capacity has been diagnosed as biological fouling/clogging of the underdrain system. Two options were evaluated to mitigate the hydraulic capacity issues, including complete rebuilding of the existing traveling bridge filters or replacing the existing system with a different style of filter, such as a cloth disc filter, which is more energy efficient.

The backwash volume for a typical traveling bridge sand filter is 5% of the applied flow, whereas for disc filters the typical backwash volume is less than 2%. The current average daily flow at the Hillsdale WWTP is 1.25 mgd. The existing traveling bridge filters are currently using over 100,000 gpd, almost double what would be expected if they could be restored to like-new condition; 5% of 1.25 mgd is 62,500 gpd. By comparison, a disc filter would require less than 25,000 gpd of backwash, a 60% reduction in backwash volume.

The backwash flow is returned to the head of the plant for additional pumping and treatment. Treatment of every gallon, even dilute backwash water that is routed through the WWTP requires energy for pumping and various other treatment processes. The backwash water is not only pumped from the tertiary filters back to the head of the plant but also up to the grit removal system through the plant influent pumps and then again up to the tertiary filters through the tertiary pumps. Additional labor and maintenance on all of the affected equipment are also factors, along with the fact that the backwash water takes up valuable treatment capacity at the WWTP.

The commodity charge, which covers operations and maintenance, for sewage treatment at Hillsdale is $3.00/1000 gallons, so the monetary value of reducing the backwash stream can be calculated. The current average daily flow is 1.25 mgd; the sand filter backwash stream of 62,500 gpd costs $68,000/year to treat. Likewise for the proposed disc filter, the backwash stream of 25,000 gpd costs $27,000/year to treat.

The cost to rehabilitate the sand filters is $722,500 and the cost to replace the sand filters with disc filters is $744,900. The simple payback to install disc filters is less than 1 year, so the disc filters are cost effective while also being more energy and water efficient than the traveling bridge sand filters. The business case shows that the disc filter components qualifies for GPR funding under Water Efficiency Sections 2.4-2 and 2.4-3 based on a reduction in backwash water.

Oxidation Ditch VFD

The oxidation ditch aerators are designed for 55 rpm to deliver the oxygen necessary to satisfy the maximum design plant BOD load. However, under average operating conditions, much less oxygen is required satisfy the demand. The energy supplied by the aerators can be reduced by lowering the liquid level in the oxidation ditches but additional energy is still being provided at typical organic loading. The aerator capacity could be reduced by an additional 33% while still meeting minimum mixing requirements and providing adequate dissolved oxygen for treatment. Under this condition, the aerator speed could be reduced to 43 rpm while maintaining sufficient energy to keep the mixed liquor in suspension at minimum depth and sufficient dissolved oxygen to treat the BOD load.

Based on the equipment supplier's calculations, the aerators will draw about 28 hp when turning at 55 rpm and only 15 hp when turning at 43 rpm. Thus, a VFD would allow the plant operator to save 46% on electric power when less than maximum organic loadings occur. Maximum loadings are estimated to occur less than 2% of the time. Overall, the VFDs will provide a 45% energy savings, therefore they qualify under 3.2-2 Energy Efficient Categorical Projects.

Conclusion

Energy efficiency is the use of improved technologies and practices to reduce the energy consumption of water quality projects, use energy in a more efficient way, and/or produce/utilize renewable energy. The proposed work items identified herein have the demonstrated ability to reduce energy consumption, use energy in a more efficient way, increase water efficiency, and/or produce renewable energy.

FLEIS&VANDENBRINK

DESIGN. BUILD. OPERATE.

Green Project Reserve - Component Summary

Client **Hillsdale BPU** *Project No.* 812230

Project 2014 Wastewater System Improvements *Date* April 2014

Item	Description	Unit	Qty.	Unit Price	Amount
1	**Headworks Building Insulation**	LS	1	$43,470	**$43,470**
2	**Headworks Building Grit Equipment Replacement**	LS	1	$208,265	**$208,265**
3	**Tertiary Pump Building Insulation**	LS	1	$18,975	**$18,975**
4	**Tertiary Filtration Replacement (Disc Filter)**	LS	1	$856,635	**$856,635**
	Anaerobic Digestion				
5	Digester Tank Improvements	LS	1	$587,995	**$587,995**
6	Biogas Handling and Safety Equipment	LS	1	$322,000	**$322,000**
7	Digester System Piping	LS	1	$230,000	**$230,000**
8	Organic Solids Recovery	LS	1	$706,905	**$706,905**
9	Electrical, Instrumentation and Controls	LS	1	$261,050	**$261,050**
10	**Renewable Energy Production (CHP)**	LS	1	$543,950	**$543,950**
11	**Main Building Insulation**	LS	1	$184,230	**$184,230**
12	**Nonpotable Water System Upgrade**	LS	1	$11,020	**$11,020**
	Subtotal				$3,974,500
	Construction Contingency	10%			**$397,000**
				Construction Subtotal:	**$4,372,000**
	Design Engineering				**$503,000**
	Construction Engineering				**$372,000**
	Legal, Bonding & Administration				**$87,000**
				Total Estimated GPR Eligible Costs:	**$5,334,000**