TOSCH'S CREEK AERATION EQUIPMENT UPGRADE — Energy Efficiency

Summary

- Replacing the four surface aerators in Aeration Basin No. 1 at the Tosch's WWTP with a diffused aeration system utilizing high-efficiency turbo blowers will greatly reduce the WWTP's energy demand.
- SRF Loan Amount = $2,952,018.00
    - $1,099,610.00 Tosch's Creek WWTP Aeration Improvements for energy efficiency
- Energy efficiency (green) portion of loan = 37.2%
    - The remaining 62.8% of the loan will be used for the headworks screening/grit removal equipment replacement and three pump station replacements.
- Annual energy savings at full design conditions = 805,920 kWh annually ($66,490 at current electric rates), and 1,217,640 kWh at average conditions ($100,460).
- At design conditions, this represents more than 38% energy savings over existing aeration equipment energy usage. At average conditions, the energy savings is greater than 57%.

Background

- Of all of the City of Union's assets and services, the Toschs Creek WWTP uses the most energy. A review of the operations indicates that replacing the aging platform aerators in Aeration Basin No. 1 with a diffused aeration system using high efficiency turbo blowers will yield energy savings.
- The energy savings is important because it will reduce the City's energy spending.
- The existing four platform aerators in Basin No. 1 consist of three 75-HP units and one 100-HP unit (325 HP total). All four aerators were installed in 1972. The aerator gear boxes were rebuilt in the 1990's. The existing aerators are single speed and energy usage is high regardless of flow through the treatment plant.
- The oxygen required for biological treatment at design conditions in Basin No. 1 is 13,757 lbs O_2/day.[1]
- At all flow conditions, the existing aerators provide approximately 1.2 – 2.4 pounds of oxygen per horsepower per hour (lbs O_2/HP-hr).[2] Given the age and wear of the aerator motors and paddles, oxygen transfer capability is likely in the low end of this range. Since the aeration basin has not experienced difficulties with treating BOD, it is assumed that the oxygen transfer capability is (13,757 lbs O_2/day / 24 hours / 325 HP) = 1.76 lbs O_2/HP-hr at design conditions.
- At design conditions for the basin, 3 MGD, the existing aerators consume 2.1 million kWh per year. The average current flow of this basin is approximately 1 MGD. At this average flow, the existing aerators still consume approximately 2.1 million kWh per year.
- For mixing purposes, all four aerators are operated at all times regardless of flow.

Results

- The new diffused aeration system will utilize a variable speed turbo blower. The speed of the new blower will be automatically adjusted based on dissolved oxygen content in the basin. The blower speed will decrease when flow is less than design conditions satisfying both oxygen and mixing requirements of the basin for proper treatment.
- At design conditions the new diffused aeration system and blowers will provide approximately 2.85 lbs O_2/HP-hr.[3] At average conditions the blower will be running at a much lower speed and using much less energy. The oxygen transfer capability at average conditions is approximately 1.39 lbs O_2/HP-hr.[3]
- At design conditions for the basin, 3 MGD, the proposed aeration system blower will utilize 1.31 million kWh per year. At the average current flow of the aeration basin (1 MGD) the proposed blower will only consume 0.90 million kWh per year.[3]

Calculated Energy Efficiency Improvements

- The oxygen transfer efficiency of the existing platform aerators is estimated to be 1.76 lbs O_2/HP-hr (please see table below for details).
- The oxygen transfer efficiency of the proposed diffused air system at design conditions is 2.85 lbs O_2/HP-hr (please see table below for details). This represents a percent energy efficiency improvement of 62%.
- The power to operate the existing platform aerators is 242 kW regardless of plant flow. The power to operate the proposed aeration system blower at design conditions is 150 kW and at average conditions, 103 kWh.
- The annual power consumption for the existing or the proposed system can be calculated from the number of hours each system operates. The aeration basin treats wastewater 365 days per year, 24 hours per day. Therefore, for the existing aerators, the estimated power consumption is 2.12 million kWh per year. For the proposed aeration system blower, the estimated power consumption is approximately 1.31 million kWh/yr at design conditions and 0.90 million kWh/yr at average conditions.
- As shown in the table below, the energy difference per year = (2,119,920 kWh – 1,314,000 kWh) = 805,920 kWh at design conditions and (2,119,920 kWh – 902,280 kWh) = 1,217,640 kWh.

Energy Efficiency Calculations for Existing Platform Aerators at Design Conditions

Description	AOR (lbs O_2/day)[a]	Oxygen Transfer Capability (O_2/HP-hr)[b]	Power Consumed (HP)[c]	Power Consumed (kW)	Annual Runtime (hr)[d]	Annual Power Consumption (kWh)[e]
Existing System	13,757	1.76	325	242	8,760	2,119,920
Proposed System	13,757	2.85	201	150	8,760	1,314,000
					Total Annual Energy Savings (kWh)[f]	805,920

Energy Efficiency Calculations for Existing Platform Aerators at Average Conditions

Description	AOR (lbs O_2/day)[a]	Oxygen Transfer Capability (O_2/HP-hr)[b]	Power Consumed (HP)[c]	Power Consumed (kW)	Annual Runtime (hr)[d]	Annual Power Consumption (kWh)[e]
Existing System	4,586	1.76	325	242	8,760	2,119,920
Proposed System	4,586	1.39	138	103	8,760	902,280
					Total Annual Energy Savings (kWh)[f]	1,217,640

Table Notes:

a. AOR = Oxygen Needed for Treatment from Section VI of the June 2011 PER for the project at design flow

b. Oxygen Transfer Capability for platform aerators from Metcalf & Eddy, 3rd Edition and blower manufacturer's information

c. HP Consumed = HP of existing aerators and AOR / 24 / oxygen transfer capability for blowers

d. Runtime from aeration required 365 days per year, 24 hours per day

e. Annual Power Consumption (kWh) = Power Required * Annual Runtime

f. Total Annual Energy Savings is the difference in annual energy between existing and proposed systems.

Conclusions

- By replacing the existing platform aerators with a diffused air system utilizing high-efficiency turbo-blowers, the Tosch's Creek WWTP will reduce energy usage by 805,920 kWh annually at design conditions, and 1,217,640 kWh at average conditions. This represents a greater than 38% reduction in energy usage at design conditions and 57% at average conditions.
- At the current rate of electricity, 8.25 cents per kWh, energy reductions from the new aeration system will save up to $66,490 at design conditions and $100,460 at average conditions per year.
- Assuming the cost to purchase and install the new aeration system is $1,099,610 then the simple payback = ($1,099,610 / $100,460/year) = 10.9 years. The City of Union anticipates a 5% annual increase in electric rates. This increase in energy cost will further reduce the payback period.
- Because the life of the diffused aeration system is 15 – 20 years, this is a reasonable payback period.

References

[1]"Preliminary Engineering Report for City of Union Tosch's Creek WWTP Headworks and Aeration Facilities and Replacement of Coleman Street, Lukesville, and Ottaray Pump Stations". Rogers and Callcott Engineers, June 2011.

[2]Wastewater Engineering Treatment, Disposal, and Reuse. Metcalf and Eddy, Inc., McGraw Hill, 3rd Edition, 1991.

[3]Oxygen transfer capability information derived from manufacturer's information for turbo blowers and fine bubble diffused aeration systems.