Performance Expected and Operational Requirements for the Arcata, CA, Wastewater Treatment Facility

By

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After reviewing several possible modifications to the Pond system at Arcata, CA, it was decided that the most feasible and dynamic approach is to use Pond 1 as an equalization basin and divide Pond 2 into two cells designed as partial mix aerated ponds (Ponds 2A and 2B). With control of the I/I in Pond 1, coupling the ponds with the upgraded wetlands should provide an effluent quality that will meet the proposed regulatory requirements. The system could perform well for many years at the proposed average flow rate of 2.3 mgd after the I/I problems are controlled or solved.

Following are presentations discussing the proposed design and operational requirements to make the system successful. All results are based on information and data provided by the City of Arcata and information found in the report by Carollo Engineering.

Discussions of several performance situations are presented in the following sections. A summary of the most severe controlling situation at the average design flow of 2.3 mgd will be presented first.

Worst Case Scenario

It seemed best to start with the likely severe design load that will enter Pond 2A during average design flow. The expected performance for the worst case scenario for the design of Ponds 2A and 2B receiving a flow rate of 2.3

mgd is shown in Table 1. It is assumed that Pond 1 will serve as an equalization pond, and that the equalization pond will not remove any BOD or ammonia-N, transferring the entire load from the clarifier to Pond 2A.

The greatest stress on Ponds 2A and 2B will occur when the water temperature is 6 degrees Celsius and microorganism growth rate is at its lowest. BOD removal in Pond 2A and Pond 2B should average approximately 70 and 27 mg/l, respectively. Ammonia-N conversion to NO_3-N likely will be minimal in Pond 2A, but it is expected that the effluent from Pond 2B will contain between 4 and 6 mg/L at the 2.3 mgd flow rate and an influent ammonia-N concentration of 55.2 mg/L. Theoretical calculations and experience with aerated ponds indicate that this level of ammonia conversion is feasible at 6 degrees Celsius (Gearheart, 2016).

Maximum power requirements as shown in Table 1 will be controlling in both cells during the warm months because of the lower solubility of oxygen at higher temperatures. The power requirements shown in Table 1 are produced by a design program that determines the controlling oxygen demand (Middlebrooks, 2005). The requirements during the cold months will be less because of the increase in solubility of oxygen and the reduced BOD and ammonia-N removed. Automated equipment should be installed to reduce the operating time for aerators used during the cold months and when power requirements might be lower after dilution of the influent during the rainy season.

During the summer and fall seasons when the flow rate is approximately 1.6 mgd, the aeration power requirements will be much less; therefore, it is essential that the aeration system be designed for control of each aerator. This will not only reduce the power consumption, but also provide better control of system performance. As pointed out above for Pond 1, the operators must be fully committed to good operation, be well informed and receive good training. There is no substitute for good operators.

As pointed out in Table 1, the power requirements are estimates that require refinement by equipment manufacturers; however the kg O_2/hr requirements must be provided by the equipment suppliers. The kg O_2/hr requirement is based on the environmental and microorganism requirements.

Based upon experience, it is best to install larger numbers of smaller aerators rather than fewer larger aerators. This approach provides better mixing, and when one or more are out of service, the power level is less affected.

Alkalinity Requirement

Because of the low concentration of alkalinity (approximately 60 mg/L) in the wastewater, to ensure good conversion of the ammonia-N to nitrate-N it will be necessary to add alkalinity to Ponds 2A or 2B. The calculation of the alkalinity needed is shown in Table 2. The adjustment to pH normally observed in facultative or lightly aerated ponds due to growth of algae will be much less prevalent than in facultative ponds and in partial-mix aerated ponds; therefore, there will be a need to supplement the limited supply of alkalinity in the wastewater. There will be a reduced concentration of algae in the aerated ponds that might help buffer the wastewater, but it is necessary to maintain the pH at 7 to maximize ammonia-N conversion.

During the summer and fall when the flow rate averages approximately 1.6 mgd, the needed alkalinity will be less, and the dosage will vary with the influent ammonia-N concentration and the influent flow rate. The influent alkalinity will vary significantly with the seasons; therefore, careful monitoring of the influent alkalinity will be needed to control costs for chemicals.

With an influent alkalinity of 60 to 100 mg/L there would be enough to convert approximately 8 to 14 mg NH_4/L to NO_3-N, respectively. Using all of the alkalinity would reduce the pH value below 7, the optimum for conversion.

Alkalinity also will be required with a carousel activated sludge process. If this was mentioned in the Corolla report I overlooked it.

Influence of I/I

As the flow increases during the rainy season, the performance in Ponds 2A and 2B will be significantly influenced by the control of the water transferred from Pond 1. Assuming good control of discharges from Pond 1, the pond system could produce a good quality effluent; however, the impact of solids washout into Pond 2A could be problematic with the first large surge of influent. Without diligent control of transfer of wastewater from Pond 1, the most dramatic effect on Ponds 2A and 2B will occur when a large rainfall occurs and washes the solids from Pond 1 into Pond 2A. Solids in Pond 1 are not similar or biologically active as those in Pond 2A and would dilute the active mass of organisms in Pond 2A. By controlling discharge from Pond 1 as diligently as possible, the system should function reasonably well throughout the year. It is imperative that washout of the active mass of solids be controlled constantly. It is essential that the operating staff be trained and educated about the urgency of flow control, and then monitor the system constantly.

With dilution of large inflow, the effects should not overwhelm the system provided the suspended solids in the pond ae not reduced to the point of biological inactivity. Also, the dramatic effect on the hydraulic retention time would significantly affect the efficiency of the system. Control of the depth of water in Pond 1 is critical if Ponds 2A and 2B are to function adequately during the rainy season. An automated depth control device is essential.

Storage Available

Normal operation of equalization ponds recommends that the depth of the pond not be drawn down below two feet to prevent odors. Following this advice, at a pond depth of 5.5 feet the volume in Pond 1 is approximately 45

MG, and at a depth of 2 feet the volume is approximately 16 MG. This leaves 29 MG for storage, which provides adequate room to control the discharge from Pond 1 if careful monitoring is exercised. Because the high rainfall occurs during the cool months, it is likely that odor control should not be a problem. Although redundant, it cannot be over emphasized that careful control of Pond 1 will determine how well Ponds 1, 2A and 2B perform; therefore, as stated above, automatic level control is highly recommended.

Impact of High Flow Rates

Flow Rate = 4.3 mgd

Assuming that the influent flow rate to Pond 2A is increased to 4.6 mgd and the BOD reduced by 50 percent, the effluent BOD would be less than that observed for the worst case scenario as shown in Table3. If the ammonia-N entering Pond 2B were also reduced to half of the influent to Pond 2A, the performance should also be equal to the worst case or less. These assumptions require a serious caveat: The accuracy of these projected effluent concentrations is dependent on to what degree the suspended solids in Ponds 2A and 2B are washed out. Doubling the flow to 4.6 with the diluted wastewater by very careful introduction of wastewater from Pond 1 that did not reduce the suspended solids concentration in the aerated pond, by more than 5 to 10 %, the performance predicted in Table 3 would likely produce an effluent quality similar to that shown. However, with aerated pond suspended solids reductions beyond the 5 to 10 %, the reduction in efficiency likely will be directly proportional to the percentage that the solids are diluted in Ponds 2A and 2B. As mentioned below, the success of the proposed system is directly related to the degree of success with controlling the discharge from Pond 1.

Flow Rate = 5.9 mgd

Assuming an influent flow rate of 5.9 mgd and dilution of the pond influent BOD and ammonia-N by a ratio of 2.565 (5.9 MGD/2.3 MGD), the design concentrations for BOD and ammonia are 71 and 21.5 mg/L, respectively.

The results of this analysis are shown in Table 4. All of the concerns apply here that were expressed in the caveat in the 4.3 mgd section. Also, there are concerns about the significant increase in flow rate that would wash out an excess quantity of suspended solids in Pond 2A unless there is careful control of discharge from Pond 1.

Projected Performance

Diligently implementing the above suggestions, the total system could produce effluent concentrations as follows: BOD < 30 mg/L, TSS 30 to 40 mg/L, ammonia-N 4 to 6 mg/L, and a pH value 7.0. The system could provide an effluent that will meet the regulatory requirements for the 20% growth projected for Arcata.

Recommendations and Comments

1. **Use Pond 1 as an equalization basin and divide Pond 2 into two cells of equal volume and designed as partial mix aerated ponds as described in this report (Ponds 2A and 2B).**
2. **Practice diligent control and use the recommendations for the pond system, and the system coupled with the upgraded wetlands could satisfy the anticipated effluent standards for many years.**
3. **Correct the I/I problem and the entire treatment system will function well without the careful control of Pond 1, and will provide treatment for the projected 20% growth to an average flow rate of 2.3 mgd for many years.**
4. **Install control equipment that will provide flexibility in control of depth in Pond 1. This is essential to ensure good performance in Ponds 2A and 2B.**

5. **Install aeration equipment with controls that will provide flexibility in operation during all seasons of the year.**
6. **Install chemical feed equipment to add alkalinity to Pond 2A with controls that will provide flexibility in operation during all seasons.**
7. **Maintain a minimum pH value of 7.0 in Ponds 2A and 2B.**
8. **Provide excellent training for the operators. Careful operation is required for peak performance from the pond system and other components of the system.**

References

Gearheart, Robert and Swanson, Chuck. 2016. Facultative Oxidation Pond Aeration,

Project Description, EIT, AMRI, January 15, 2016.

Middlebrooks, E. Joe. 2005. Program for Partial-Mix Aerated Wastewater Stabilization Pond Design, With Known Temperature and Hydraulic Detention Time.

Table 1. Expected treatment in Pond 2A and 2B at design flow rate of 2.3 mgd at various water temperatures when Pond 2 is divided into two equal cells.

Assuming Pond 1 Does Not Remove any BOD or NH3-N. (Worst Case Scenario). Design based on average design flow rate of 2.3 mgd , and assuming 30% BOD removal in primary tank influent of 260 mg/L.

Water Temperature Degrees Celsius	Pond 2A Effluent BOD Flow Rate = 2.3 mgd Inf. BOD = 182 mg/L mg/L	Pond 2A Dissolved Oxygen Requirement for BOD Without Correction for Equipment Efficiency[a] kg O_2/hr[b]	kW Required In Pond 2A for BOD at 2.3 mgd kW[b]
6	69.38	153.56	80.82
10	63.41	156.95	82.61
15	56.32	160.06	84.24
20	49.68	161.98	85.25
25	43.56	162.92	85.75
30	37.97	163.12	85.85
35	32.93	162.74	85.65

[a]Excludes correction for equipment efficiencies , but Includes environmental corrections and multiplying factor of 1.5 for BOD removal.

[b]Controlled by Summer Temperature.

[c]These power req. are approximate values and are used for the preliminary selection of equipment. These values are used in conjunction with equipment manufacturers catalogs to select the proper equipment.

Table 1 Cont. Expected treatment in Pond 2A and 2B at design flow rate of 2.3 mgd at various water temperatures when Pond 2 is divided into two equal cells.

Assuming Pond 1 Does Not Remove any BOD or NH3-N. (Worst Case Scenario). Design based on average design flow rate of 2.3 mgd , and assuming 30% BOD removal in primary tank influent of 260 mg/L.

Pond 2B Effluent BOD Flow Rate = 2.3 mgd Inf. BOD = Col. B mg/L	Pond 2B Dissolved Oxygen Requirement for BOD Without Correction for Equipment Efficiency[a] kg O_2/hr[b]	kW Required In Pond 2B for BOD at 2.3 mgd kW[b]	Pond 2B Dissolved Oxygen Requirement for NH_3-N Without Correction for Equipment Efficiency[a] kg O_2/hr[b]
26.45	51.55	27.13	132.39
22.10	48.03	25.28	135.32
17.45	43.34	22.81	138.00
13.56	38.54	20.28	139.66
10.42	33.84	17.81	140.46
7.92	29.39	15.47	140.64
5.96	25.30	13.32	140.31

[a]Excludes correction for equipment efficiencies , but Includes environmental corrections and multiplying factor of 1.5 for BOD removal.

[b]Controlled by Summer Temperature.

[c]These power req. are approximate values and are used for the preliminary selection of equipment. These values are used in conjunction with equipment manufacturers catalogs to select the proper equipment.

Table 1 Cont. Expected treatment in Pond 2A and 2B at design flow rate of 2.3 mgd at various water temperatures when Pond 2 is divided into two equal cells.

Assuming Pond 1 Does Not Remove any BOD or NH_3-N. (Worst Case Scenario). Design based on average design flow rate of 2.3 mgd , and assuming 30% BOD removal in primary tank influent of 260 mg/L.

kW Required In Pond 2B for NH_3-N at 2.3 mgd kWb	Total Oxygen Demand for Pond 2B Flow rate = 2.3 mgd kg O_2/hrb	Total kW Required for Pond 2 Flow Rate = 2.3 mgd kWb	Total hp Required for Pond 2 Flow Rate = 2.3 mgd hpb
69.68	337.5	177.63	238.20
71.22	340.3	179.11	240.19
72.63	341.4	179.68	240.95
73.50	340.18	179.03	240.08
73.93	337.22	177.49	238.01
74.02	333.15	175.34	235.13
73.65	328.35	172.62	231.48

aExcludes correction for equipment efficiencies , but Includes environmental corrections and multiplying factor of 1.5 for BOD removal.

bControlled by Summer Temperature.

cThese power req. are approximate values and are used for the preliminary selection of equipment. These values are used in conjunction with equipment manufacturers catalogs to select the proper equipment.

Table 2. Alkalinity in the wastewater is consumed during the process; therefore, must calculate needed alkalinity for 2.3 mgd.

Flow rate =	**8706.5**	**m^3/d**
Influent Alkalinity	**60**	**mg/L**
Influent Total Nitrogen =	**55.2**	**mg/L**
Assumed conversion =	**0.96**	
NO_3 = TN - Ne	**53.0**	**mg/L**
Influent Alkalinity	**60**	**mg/L**
Alk. used for nitrif. = (7.14 g $CaCO_3$/gNH_4-N)(NO_x) =	**378**	**mg/L used as $CaCO_3$**
Alkalinity Residual needed to maintain pH at 7 =	**80**	**mg/L as $CaCO_3$**
Alk to maintain pH at approx. 7 = Alk Used + Residual Alk. to maintain pH 7 - Inf. Alk	**398.4**	**mg/L as $CaCO_3$**
Alkalinity Needed =	**3468**	**kg/d as $CaCO_3$**

Table 3. Expected treatment in Ponds 2A and 2B at Various Temperatures and 4.6 mgd.

Water Temperature Degrees Celsius	Pond 2A Effluent BOD Flow Rate =4.6 mgd Inf. BOD = 91 mg/L mg/L	Pond 2A kg O2/hr Required at 4.6 mgd	Pond 2B Effluent BOD Flow Rate = 4.6 mgd Inf. BOD = 2A Effluent mg/L	Pond 2B kg O2/hr Required at 4.6 mgd	Pond 2B Dissolved Oxygen Requirement for NH_3-N Influent = 27.6 mg/L kg O_2/hr
6	50.23	153.55	27.73	74.65	122.04
8	48.63	155.35	25.99	73.03	123.47
10	47.03	156.95	24.30	71.24	124.74
15	43.01	160.06	20.33	66.20	127.21
20	39.03	161.98	16.74	60.55	128.74
25	35.14	162.92	13.57	54.61	129.49
30	31.41	163.12	10.84	48.64	129.65
35	27.88	162.74	8.54	42.85	129.35

Table 4. Expected treatment in Ponds 2A and 2B at Various Temperatures and 5.9 mgd.

Water Temperature Degrees Celsius	Pond 2A Effluent BOD Flow Rate = 5.9 mgd Inf. BOD = 91 mg/L mg/L	Pond 2A kg O2/hr Required at 5.9 mgd	Pond 2B Effluent BOD Flow Rate = 5.9 mgd Inf. BOD = 2A Effluent mg/L	Pond 2B kg O2/hr Required at 5.9 mgd	Pond 2B Dissolved Oxygen Requirement for NH_3-N Influent = 27.6 mg/L kg O_2/hr
6	34.69	196.95	13.22	66.12	156.4
8	33.18	199.26	12.1	63.91	156.4
10	31.71	201.31	11.05	61.61	156.4
15	28.16	205.29	8.71	55.59	156.4
20	24.84	207.76	6.78	49.43	156.4
25	21.78	208.17	5.21	47.89	156.4
30	18.98	209.22	3.96	37.70	156.4
35	16.46	208.74	2.98	32.45	156.4