

## Technical Summary of VaraCorp Aerator Performance at an Above Ground Storage Tank Produced Water Treatment Facility

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Date: March 3, 2015

### Scope

Investigate performance of VaraCorp Turbine Aerators in an Above Ground Storage Tank (AST) used to stage treated produced and flowback water at an existing operating treatment facility.

### System Configuration

Effluent from a Rockwater Energy treatment facility was dosed with sodium hypochlorite and TTPC prior to staging in one of four 40,000 bbl capacity Rockwater ASTs. The AST's were equipped with three 3 HP VaraCorp Turbine Aerators, a floating membrane cover (~90% coverage), a hydronic system for temperature control, and tank recirculation.

Test duration was approximately one month (12/29/14-1/29/15). AST 2 was first filled with treated water, then transferred to AST 1 on 1/9/15. AST 1 stored volume was approximately 36,000 bbl. AST 1 aerators and temperature control (~85 oF) remained operational during the test. However, foam buildup around the aerator pontoons/motors was observed during this time. Recirculation (0.6 tank turns/day) was also functional, except a four day period where it was shut down. Target dissolved oxygen (DO) concentration to sustain aerobic conditions in the ASTs is greater than 2 ppm.

### Results

COD/BOD<sub>5</sub>/NH<sub>3</sub> samples were taken from AST 1 and AST 2 on 1/21/15. The results are shown in Table 1. Assuming AST 2 results are representative of AST 1 initial oxygen demand, the resulting decrease in chemical oxygen demand (COD) for the 12 day duration (1/9 to 1/21) computes to 4.7 lbs O<sub>2</sub>/HP-hr (assumes shaft HP is 2, per VaraCorp ). BOD<sub>5</sub>/COD/NH<sub>3</sub> reduction was 65%, 51%, and 14%, respectively. Through extrapolation, and using initial COD loading and calculated aerator performance, the estimated time to satisfy DO target is 24 days.

Table 1. 1/21/15 Analytical Results

|       | Sample Concentration                       |                               |                                | Total Tank Load           |              |                          |
|-------|--|-------------------------------|--------------------------------|---------------------------|--------------|--------------------------|
|       | BOD <sub>5</sub><br>(mg/L O <sub>2</sub> ) | COD<br>(mg/L O <sub>2</sub> ) | NH <sub>3</sub><br>(mg/L as N) | BOD <sub>5</sub><br>(lbs) | COD<br>(lbs) | NH <sub>3</sub><br>(lbs) |
| AST 1 | 176  | 620                           | 38                             | 2208                      | 7778         | 477                      |
| AST 2 | 525  | 1310                          | 46                             | 6361                      | 15871        | 557                      |

Actual measured DO trend in AST 1 is shown below in Figure 1. Note that AST 1 DO concentration immediately after fill decreased to near zero, and remained near zero for about 18 days, then increased rapidly once aerobic conditions were satisfied.

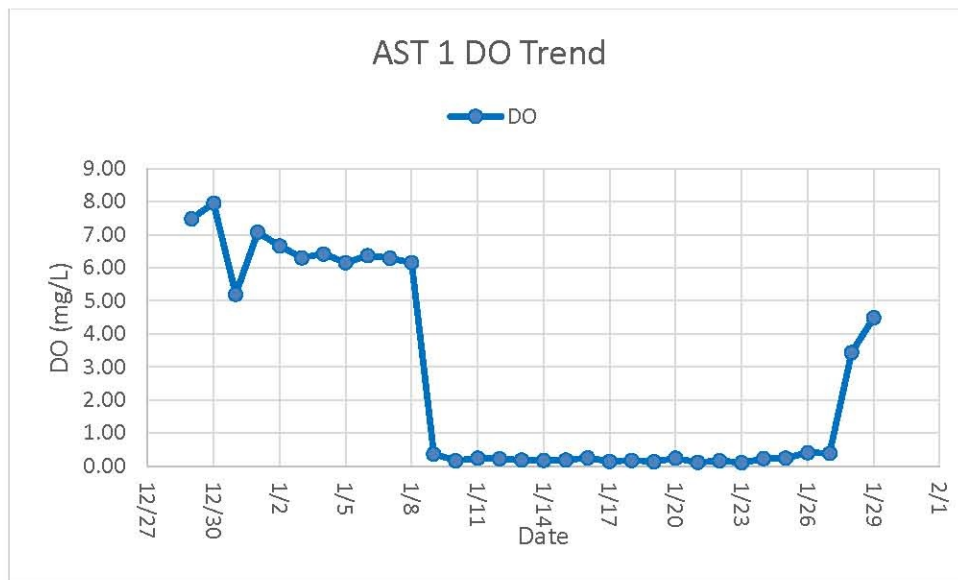


Figure 1. AST 1 DO Trend Over Test Period

### Conclusion

Given the challenges unique to this application (significant inlet COD/BOD<sub>5</sub>/NH<sub>3</sub>, foam impeding aerator air inlet, floating liner restricting natural O<sub>2</sub> transfer in and CO<sub>2</sub>/organic gas out), the VaraCorp aerators performed satisfactorily. The actual time required to establish aerobic conditions in AST 1 was 18 days, compared to the empirically based projection of 24 days. It is likely the water temperature control and recirculation systems helped minimize DO response time, however, data was not collected during the test period to support this statement.