ALCOA – MT. HOLLY ZERO PROCESS WATER DISCHARGE USING PHYTOTECHNOLOGY

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Abstract. Alcoa – Mt. Holly is a primary aluminum reduction facility that produces primary aluminum ingot. Approximately 70,000 gallons of process cooling water are generated each day, including cooling tower blow down and wash waters, which flow to a common sump. The sump discharges to a 2.1 million gallon clay-lined process lagoon located south of the main plant area. From 1980 until 1997 the process water was applied to a 28-acre spray field adjacent to the process lagoon. In 1997, the sprayfield was decommissioned and the process water from the lagoon was routed to the Berkeley County Water & Sanitation Authority POTW.

Alcoa has adopted a sustainability goal to achieve zero process wastewater discharge by 2020. Beginning in 2002, the Mt. Holly facility evaluated phytotechnology for process water management, focusing on reducing discharge volume. The phytotechnology mechanisms selected for the site were Evapotranspiration, and Phytostabilization (sequestering of inorganics in the rhizosphere). The site conditions of the closed sprayfield were evaluated to determine its suitability for application of phytotechnology.

Rooting tests were conducted to identify sprayfield soil conditions and to determine the tree and grass species most appropriate for the process water land application. A pilot project consisting of 1.33 acres of OP-367 Hybrid Poplars (~1,200 trees) and 1.33 acres of native grasses was permitted under a No Discharge (ND) Permit with SCDHEC and constructed in 2002. An onsite weather station and PLC control the application and spray schemes in compliance with the ND Permit. Semiannual groundwater samples and annual soil samples are taken to ensure there are no impacts from spraying.

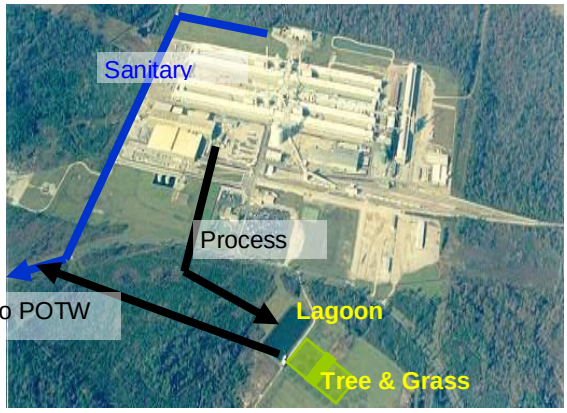
The trees are currently in their sixth growing season and have reached a height of approximately 35ft and a girth of 1ft. Mortality rate has been 9.8 percent, primarily due to isolated wet conditions in low-lying areas, and from wind damage. Willow trees have been used as replacements in the wet areas. As the trees matured, application of total effluent to the Sprayfield has increased from 9.6 percent in 2005 to 19.8 percent in 2007. Performance of the tree plot has been better than the grass plot based on field observations and flow data. Soil and groundwater monitoring data has shown no increase in constituents of interest in the effluent being applied to the Sprayfield.

A full-scale sprayfield phytotechnology plot expansion to 13.1 acres is currently being designed and permitted, and should be constructed in 2008. The expansion will include lessons learned from the pilot study. Trees will be planted in the grass section, and the expanded plot will utilize the available high ground within the original 28 acres. The expanded project is expected to achieve the zero process water discharge goal.

BACKGROUND

Alcoa – Mt. Holly is a primary aluminum reduction facility that produces primary aluminum ingot. Approximately 70,000 gallons of process cooling water are generated each day, including cooling tower blow down and wash waters, which flow to a common sump. The sump discharges to a 2.1 million gallon clay-lined process lagoon located south of the main plant area. From 1980 until 1997 the process water was applied to a 28-acre spray field adjacent to the process lagoon. In 1997, the sprayfield was decommissioned due to ponding in some areas and the process water from the lagoon was routed to the Berkeley County Water & Sanitation POTW.

In 2002, Alcoa adopted a sustainability goal for its worldwide operations to achieve zero process wastewater discharge by 2020. As part of this effort, the Mt. Holly facility installed two 1.3-acre pilot plots in Zone 3 of the former sprayfield. Berms were constructed around the perimeter of each pilot plot to ensure land applied process water remained within the confined regulated plots. Process water not consumed by the pilot plots was discharged to Berkeley County Water & Sanitation. The first plot was composed of 1,131 hybrid poplar cultivars, while the second plot was composed of native grasses observed in the study area.



Mt. Holly tree and grass pilot plots.

PROJECT OBJECTIVES

The objective of the pilot-scale study was to validate the applicability of using phytotechnologies as an effective means to both sequester constituents of interest (COIs) and reduce the volume of process waster discharged to the BCWSA. Based on the historical monitoring data, the pilot-scale study was tailored to the following COIs: fluoride, copper, nickel and zinc. To realize this objective, two pilot plots were planted and irrigated with water diverted from the process lagoon. The goals of this pilot study were as follows:

- Identify the site-specific evapotranspiration loss capacities of the plant species used in the project;
- Document the environmental fate of the COIs in the pilot plot soils, rhizosphere and vegetative portions of the trees and grass;
- Demonstrate optimal hydraulic loading and consumptive use rates that would be protective of surface water and groundwater;
- Demonstrate seasonal performance capabilities and potential limitations of the system; and
- Determine the applicability of using phytotechnologies to sequester/transform the COIs and to consumptively utilize process water on an expanded basis at the Mt Holly Site, or at other Alcoa facilities worldwide.

PROJECT DESCRIPTION: PRE-DESIGN ANALYSIS

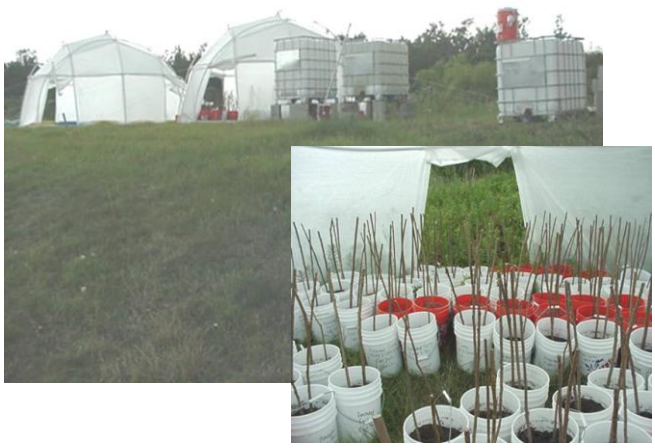
Prior to implementation of the pilot plantings, a multifaceted pre-design analysis was performed in 2002 to generate the site-specific data necessary to prepare final engineering plans for the pilot study. The specific work elements conducted during the pre-design analysis included soils sampling and analysis, percolation testing, water quality characterization analyses, and rooting test experiments.

Representative soil samples were collected from each of the two pilot plot areas comprising the sprayfield system. Soil data indicated that the sprayfield soils could be conditioned to support tree/grass growth with the proper additions of nutrient and organic amendments. Soil test pit observations showed black sandy loam with underlying clay layers. A hard pan layer was present at the sandy soil/clay interface (48 to 60 inches below ground surface). Hard pan was broken in suspected areas and areas with too much or too little top soil were re-graded.

A series of field percolation tests were performed in the phyto plot areas to quantify water infiltration rates. The average daily infiltration rates ranged from 4.17 inches per day in the grass plot area to 5.43 inches per day in the tree planting area. The findings of the percolation tests indicated that adequate infiltration capacities are present in most areas of the pilot plot planting zones in both pilot plot areas.

Water quality samples were collected from the process lagoon to supplement the existing data set, fully characterize the properties of the site process water, and obtain additional performance data necessary to evaluate appropriate water application rates. Results indicated the high ionic strength process water was slightly alkaline (pH 8.6), primarily comprised of inorganic constituents and relatively low metal concentrations.

Rooting test investigations were conducted at the Site to identify the ability of site soils to support and sustain a viable vegetative community and the most appropriate tree species to be used in the pilot studies. Rooting test results indicated the hybrid poplar cultivars OP-367 performed well under all test scenarios. The amended sprayfield soils proved slightly more supportive of tree development than the unamended soils.



Rooting tests.

PROJECT DESCRIPTION – PERMIT REQUIREMENTS

In April 2003 SC DHEC issued a land application permit to Alcoa – Mt. Holly for process water consumption on a 1.3 acre pyto plot and a 1.3 acre native grass plot. Requirements in this permit include appropriate weather conditions, daily site inspections when spraying, and groundwater and soil sampling, and process water monitoring.

In order to apply process water to the sprayfield, ambient temperature must be above 35 degrees Fahrenheit, wind speed must be less than 30 mph, and rainfall must be less than 0.1 inches. A weather station was installed at the sprayfield to record real time weather data, which is programmed into a PLC to control spraying.

The PLC has also been programmed to ensure compliance with the permit requirement of a daily field inspection prior to initiating land application. The system automatically shuts off at 7pm and requires an inspector to manually start the system the next day after completing an inspection. Several of Mt. Holly's environmental technicians are trained to conduct the inspection of the sprayfield and to troubleshoot its associated equipment.

Monthly monitoring of COIs in the process water lagoon effluent is required under the No Discharge permit. Semi-annual groundwater samples and annual soil samples are required to ensure there are no unacceptable impacts from spraying. COIs are monitored in three groundwater monitoring wells (MW-10, MW-11, and MW-12) and in soil at three locations in each plot.

RESULTS AND DISCUSSION

The trees are currently in their sixth growing season and have reached a height of approximately 35ft and a girth of 1ft. Mortality rate has been 9.8 percent, primarily due to isolated wet conditions in low-lying areas, and from wind damage. Willow trees have been used as replacements in the wet areas. Spray heads have been turned off to reduce the application rate in these areas.

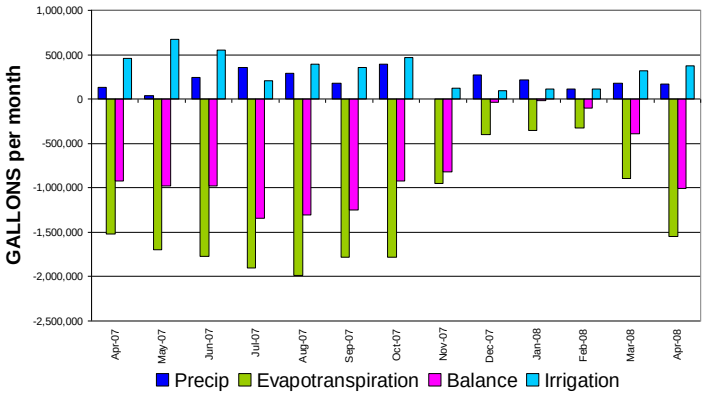
A water balance was used to evaluate the role of the pilot plot vegetation in removing soil moisture via evapotranspiration. As the hybrid poplar trees matured, the total volume of process water application increased. By 2005, over one million gallons of process water was applied to both the grass and tree plots. Peak monthly application reached 360,000 gallons in July 2006. As the trees matured, application of total effluent to the Sprayfield has increased from 9.6 percent in 2005 to 19.8 percent in 2007.

Current 6 year trees.

Soil and groundwater monitoring data has shown no increase in constituents of interest in the effluent being applied to the Sprayfield. Fluoride groundwater concentrations have remained significantly less than levels observed within the process lagoon. These results indicate the process waters have not infiltrated through to groundwater. Similarly, nickel, copper, and zinc concentrations have remained below levels in the process water lagoon, and have been consistent with background groundwater levels. In November 2004, nickel copper and zinc concentrations in the pilot plot groundwater temporarily increased due to high turbidity levels taken during the November 2004 sampling event. Groundwater sampling methods have since been changed to using a low flow peristaltic pump which avoids high turbidity levels.

Performance of the tree plot has been better than the grass plot based on field observations and flow data. The annual water balance summaries for the pyto and grass plots support this statement. In 2004, the hybrid poplars began to transpire approximately 120,000 gallons more than the grass control. By 2007, the hybrid poplar plot transpired approximately 300,000 gallons more than the grassed plot.

5 Year Trees - Current Plots (1,160 trees)



FUTURE DIRECTION

To further attain Alcoa's goal of reducing process wastewater discharges to surface water by 100 percent by 2020, the process water discharge to the BCWSA must be balanced through the effective evapotranspiration by the hybrid poplar plot. To achieve this balance, the current pilot hybrid poplar plot would need to be expanded an additional ten and a half acres (total trees = 11,500; 13.1 acres).

Expansion of the hybrid poplar sprayfield would require upgrade and modifications to the existing sprayfield irrigation system including pumps and appurtenances. Additional monitoring wells and piezometers would also be required to effectively monitor the performance of the plot and maintain compliance with the existing permit.

A full-scale sprayfield phytotechnology plot expansion to 13.1 acres is currently being designed and permitted, and should be constructed in late 2008 or early 2009. The expansion will include lessons learned from the pilot study. Trees will be planted in the grass section, and the expanded plot will utilize the available high ground within the original 28 acres. The expanded project is expected to achieve the zero process water discharge goal once trees reach maturity in 2013.

Mt. Holly sprayfield.