COST-EFFECTIVE UPGRADING OF A SMALL POTW WITH CONSTRUCTED WETLANDS USING A COOPERATIVE FUNDING AND CONSTRUCTION APPROACH

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Abstract. Constructed Wetlands can cost-effectively improve the water quality of the effluent of domestic wastewater treatment plants to a point that ensures compliance with discharge limits and facilitates reuse of the effluent. This paper describes a project that will demonstrate that effectiveness on a cost and treatment basis. The target effluent parameters are ammonia and total phosphorus in the summer months (March through October) with a monthly average of 2.0mg/l and weekly average of 3.0mg/l.

INTRODUCTION

The purpose of this project was to demonstrate the effectiveness on a cost and treatment basis of a constructed wetland to polish the effluent from a small domestic municipal wastewater plant. The ultimate goal of adding this polishing process was to cost-effectively improve the water quality of the effluent to a point that insures compliance with stringent phosphorus and nitrogen discharge limits and encourages and facilitates reuse of the effluent to irrigate native plants and landscaping. Keowee Key Utility Systems (KKUS), located in Salem, South Carolina, serves a small residential community located on Lake Keowee in the northwest corner of the State. The 2,200 homes are served by a secondary treatment plant that currently discharges it's effluent to a tributary of Lake Keowee. KKUS voluntarily constructed the polishing wetland to ensure summer compliance with ammonia and phosphorus discharge limits, to improve water quality in Lake Keowee, and to achieve an effluent that could be reused through landscape irrigation.

The overall concept of the proposed design relied on a constructed wetland cell with sufficient capacity and detention time to treat the targeted wastewater constituents. The tertiary or polishing process applied was surface flow constructed wetlands using broad-leaf cattails (*Typha Latifolia*). The modifications required included modifying the effluent piping (which delivers the effluent to), a wetland cell, and wetland effluent piping. The design was based upon an average daily flow of 200,000 gal with a maximum flow of 350,000 gpd and minimum flow of 75,000 gpd. The design was based upon gravity flow of secondary effluent from the current treatment system through the constructed wetland. The wetland cell is located after effluent chlorination and before flow monitoring, post aeration (by step aeration) and discharge. The design and construction of the $40,000 project was funded using a cooperative approach between the Utility, the Keowee Key Property Owners Association, Clemson University, and local volunteers.

DESIGN CONSIDERATIONS AND CONCEPT

This constructed wetland is designed to achieve the project objectives and to provide insurance that the effluent meets or exceeds requirements of the National Pollutant Discharge Elimination System (NPDES) permit requirements. The targeted effluent constituents are phosphorus and ammonia of 2.0mg/l monthly average and 3.0mg/l weekly average during the summer months. This design incorporates fundamental biogeochemical processes that occur in constructed wetlands to transfer or that transform targeted constituents of the wastewater. The design is based upon gravity flow of the secondary effluent from the current treatment system to the wetland constructed in the area previously used as a polishing pond. The effluent piping was modified by adding a tee and two plug valves in the effluent sewer and a wetland distribution header in the wetland cell. The distribution piping will split the flow into four separate pipes each equipped with a PVC shear gate valve designed for on/off service. The flow into each area of the wetland

cell is distributed across that portion of the cell by a series of drilled holes in the header. The outflow piping from each area of the wetland cell will be directed to an old effluent pipe from the abandoned polishing pond and will flow to the post aeration unit. The effluent of the post aeration unit will enter the current discharge pipe to a tributary of Lake Keowee or may be later directed to irrigate demonstration plots.

The total acreage of constructed wetland cells to treat the 200,000 gpd is 1.4 acres. This area is 200' wide by 300' long with an average water depth of about 1 foot. The 1-ft. of water depth provides 54.6 hours of hydraulic detention time for the 200,000 gpd average flow. Each of the four portions of the wetland cell is equipped with a prefabricated PVC outlet box equipped with stop logs to adjust water level. The effluent from each outlet box drains to a collection header, which is connected to the old polishing pond discharge piping that flows to the post aeration unit (step aeration). The wetland cell was constructed by excavating and filling the old polishing pond, installing a compacted clay layer to restrict infiltration, and installing an 18-inch thick layer of soil (hydrosoil) for a growing media. The wetland was planted with 3,000 cattails on 24-inch centers, each way. When the cattails mature they will be harvested to remove the nitrogen and phosphorus the have taken from the effluent.

PROJECTED PERFORMANCE

Fertilizer was not added to the hydrosoil to encourage the cattails to uptake nitrogen and phosphorus from the effluent. We are anticipating a 40-50% reduction in the ammonia, total phosphorus, BOD, and fecal coliform in the effluent based on uptake, sedimentation, biological oxidation, and natural die-off, respectively. The table below lists the targeted constituents and the strategy for their reduction in the wetland.

Table 1. Targeted Constituents and Treatment Strategy

Targeted Constituents	Treatment Mechanism	Contact Time Required
Biochemical Oxygen Demand	Biological Oxidation	48 hrs.
Total Suspended Solids	Settling (Stokes Law)	24 hrs.
NH_3-N	Uptake (Plants and Bacteria) Oxidation	48 hrs.
Fecal Coliform	Settling, Sorption	48 hrs.
Total Phosphorus	Uptake (Plants and Bacteria)	48 hrs.

PROJECT COST CONTROL

The capital cost of the project was kept under $40,000 by KKUS by: 1) selecting a natural process; 2) using a low cost design approach; 3) self-performing purchasing, pipeline and equipment installation work; 4) obtaining technical support and the plants from the Clemson Institute of Environmental Toxicology (CIET), and 5) using labor from graduate students and local volunteers for wetland planting and landscaping activities. KKUS self-performed all the labor tasks except the earthwork and grading required to fill in the old polishing pond and reshape the area for the wetland cell. The project was completed by KKUS for less than $40,000 out of pocket as presented in the table below.

Table 2. Out of Pocket Cost for KKUS Polishing Wetland

Cost Category	Cost
1. Earthwork and Grading	$21,017
2. Piping, Valves, etc.	$6,833
3. Parshall Flume and Ultrasonic Flow Meter	$3,200
4. Wetland Outlet Boxes	$976
5. Hydro Seeding Banks	$1,200
6. Incidentals	$1,000
7. Engineering and Permitting	$4,000
Total Project	$38,222

RESULTS

Basic construction of the polishing wetlands was completed and the plants installed in September of 2002. Graduate students from the CIET volunteered their time to install the 3,000 plants, which were provided by the CIET. The graduate students are utilizing wastewater from the treatment plant and the wetland cell for a number of research studies. Immediately after planting was completed a portion of the effluent was directed to the wetlands to help the plants become acclimated. After three weeks when the plants showed signs of growth the full effluent stream was directed through the wetlands. Even though the cattails appear dormant root growth will continue through the winter and we are experiencing a reduction in fecal coliform and phosphorus. We anticipate a major expansion of the area covered by the cattails by spring and plan to fully evaluate the performance of the wetlands in the critical summer months (for fecal coliform, nitrogen, and phosphorus) in the summer of 2003. The entire area of the wetland cell should be covered by the end of the second growing season.

KKUS has also completed the construction of an innovative solar dryer for their waste sludge. The unit utilizes a drying bed, a greenhouse-like chamber whose environment is microprocessor controlled, and a computerized "mole" which tills the sludge exposing new solids to the air and opening additional drainage paths for free water. Sludge dryness of 50 to 90% can be achieved with low energy and operating costs. The harvested cattails from the wetland can be mulched and mixed with the dried sludge to form a nitrogen-rich Class A fertilizer.

DISCUSSION

In January of this year KKUS accepted the 2002 Conservation Award from the South Carolina Wildlife Association. KKUS was selected for the Water Award fro demonstrating their commitment to protecting the water quality of Lake Kewoee by installing the sludge dryer and by voluntarily adding the polishing wetlands to their treatment system. The project has successfully demonstrated that a polishing wetland can be added to a domestic wastewater treatment plant for a minimal capital cost (for this project only $0.20 per gallon of treatment capacity). Working on this project has been a very satisfying opportunity and we (the authors) are looking forward to evaluating the wetland's performance in reducing BOD, fecal coliform, ammonia, and total phosphorus as it matures during the critical summer months of 2003.

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