

UC Berkeley

Hydrology

Title

Channel Design to Increase Wastewater Treatment Wetland Capacity and Connectivity in Stockton, CA

Permalink

<https://escholarship.org/uc/item/4f91r04k>

Author

Cubbison, Erin O.

Publication Date

2006-05-24

Supplemental Material

<https://escholarship.org/uc/item/4f91r04k#supplemental>

Channel Design to Increase Wastewater Treatment Wetland Capacity and Connectivity in Stockton, CA

Erin O'Mahoney Cubbison
Final Draft
May 24, 2006

Abstract

This research investigates how a new channel may be designed and integrated to improve the capacity and community connectivity of wastewater treatment wetlands at the Stockton Regional Water Control Facility. It is becoming more common for treatment facilities to integrate natural techniques into the conventional treatment processes. Currently, the wetlands at Stockton are used as one stage in the water treatment process. They are fed by pipeline which conveys the water from the previous treatment stage, the facultative algal ponds, to the west edge of the wetlands. The primary function of the wetlands is to provide treatment for suspended organic solids and nutrients. The current pipeline provides no treatment to the water and is only used to convey the water. As described by Greg White, manager at the facility, it is also their goal to build an educational path and platform system, which will allow visitors to experience the wetlands. By replacing the existing pipeline with a channel, the goals of this investigation are to provide additional water treatment capacity in the channel itself and to integrate educational and recreational spaces for the community. As a designer, this research has allowed me to approach the design for a new channel at the Stockton Regional Water Control Facility in a comprehensive and scientific way. I developed a design process comprised of both quantitative and qualitative evaluations and decisions. In this way, I satisfied hydraulic principles and equations while accomplishing landscape design goals.

Problem Statement

Many conventional wastewater treatment facilities typically involve built structures for water containment, chemicals, and isolation from public access. The structures are of fixed size, positioned on paved lots or properties, and connected by pipeline and pumping. Currently, it is becoming more common for facilities to integrate natural techniques into their treatment process. This often takes the form of wetlands, which perform several functions. They allow suspended solids to settle out of the water; they support plants which remove nutrients from the water; they create habitat for wildlife; and they create recreational and education areas for the public. Wetlands may represent different proportions within the overall treatment process, from playing a minor role to a major one.

Once established, treatment wetlands require little maintenance during normal operation. Routine maintenance is expected to include daily monitoring of water levels and control structures, water quality sampling and data analysis, vegetation management, vector (e.g. mosquito and midge) monitoring and management, public use and access facility management, and berm maintenance and repair. (OMI/Thames. *Stockton*, 14.)

In the case of Stockton, California's treatment facility, the wetlands, while occupying an impressive amount of square footage, approximately 160 acres (Frank, 3), perform one stage of the treatment process. In contrast, wetlands may also perform many or nearly all stages of the treatment process as demonstrated by Advanced Ecologically Engineered Systems, the current term for what used to be called Living Machines (Slater, April 14, 2006).

This research investigates how a new channel may be designed and integrated to improve the capacity and community connectivity of wastewater treatment wetlands, specifically using Stockton Regional Water Control Facility as a case study (Figure 1). Currently, the wetlands are used as one stage in the water treatment process for the city of Stockton, California. They are fed by a 62" diameter pipeline (Figure 2) which moves water from the facultative algal ponds, one of the stages of conventional wastewater treatment, to the west edge of the wetlands (Figure 3). The function of the wetlands is to provide treatment for suspended organic solids and nutrients. The current pipeline only conveys the

water from one place to another, providing no treatment of the water. As described by Greg White, manager at the facility, it is also their goal to build an educational path and platform system, which will allow visitors to experience the wetlands. By replacing the existing pipeline with a channel, the goals of this investigation are to provide additional water treatment capacity through the channel itself and to integrate educational and recreational spaces for the community.

Methods

The methods for this research include preliminary and follow-up interviews with professionals in the wastewater industry, the collection of recorded wastewater flow data from OMI/Thames, and a site visit to Stockton Regional Water Control Facility. I interviewed Cole Slater, Engineer, CH2MHILL, regarding current trends in wastewater treatment and the function of different techniques or stages in treatment; Paul Frank, Engineer, CH2MHILL, regarding the original design criteria for the wetlands and how it fits in to the overall treatment process. He also provided me with a graphic diagram of the original design for the wetlands (Figure 4); and Greg White, Manager, OMI/Thames Municipal Utilities Department, Stockton, California, regarding how the wetlands design changed and was built. Greg White led me on a guided site visit of the facility and wetlands and explained in detail each stage of the process as well as the role of the wetlands. He also provided average daily flow data for each month (May 2005-May 2006). Through the site visit, I learned how the wetlands were actually built and function, confirmed aerial photograph distances, and evaluated the possible channel positions, dimensions, and connections (Figure 5).

The next phase of my methods involved compiling the information and developing the design process. I used a design process that was both qualitative and quantitative in nature. The qualitative aspects included adjacency considerations with the other stages of treatment, landscape design issues, such as spatial definition and access, and considerations for public use. The quantitative methods consisted of balancing the design criteria for the wetland with channel characteristics such as the plan, cross section,

and flow calculations. The calculations I used include Design Criteria (Flow), the Cowan Method for the Estimation of the Roughness Coefficient, Hydraulic Radius, Manning Equation for Open Channel Flow, and Total Discharge Rate, (Tables 1-5). I used linked formula spreadsheets to coordinate the criteria and values for the various parts of the channel design.

Results

The results of the interviews and data collection yielded the following criteria relevant to the channel design. The wetland consists of two types of zones, deep and shallow (Figure 4), which are arranged perpendicular to the direction of flow. The deep zones “distribute flow, increase hydraulic residence time, allow for settling of particulate matter, and create a greater diversity of habitat” (OMI/Thames Stockton, 13). The design depth for the deep zones is 5 feet. The shallow zones “will be planted with a variety of aquatic species tolerant of continuous flooding, such as broadleaf arrowhead (*Sagittaria latifolia*), California bulrush (*Scirpus californicus*) ...and common cattail (*Juncus balticus*)” (Ibid) (Figure 6). While the primary function of the deep zones is to promote mixing, the primary function of the shallow zones is to provide surfaces, or “obstacles” for the suspended organic matter to cling to, in order to settle out of the water (Frank, April 21, 2006).

According to *Stockton Regional Wastewater Control Facility Basis for Design*, “The target ratio of marsh [shallow] area to deep area is 80:20” (13). As such, I based the design of the channel on this ratio of the wetlands. The new channel would need to include both deep and shallow sections which run perpendicular to the flow of water. This to ensure that all water moves through all deep and shallow sections and no “short-circuiting” occurs (White, May 17, 2006). Since the channel can be seen as a linear element, I used a module to design the shallow: deep ratio of 80:20. I based the module on 10,000 square feet, a size that is both reasonable for the scale of the site as well as beneficial for landscape design considerations. In plan, for every 10,000 square feet of channel, there is an 8,000 square foot shallow section, and 2,000 square foot deep section. The module then continuously repeats,

from the beginning of the channel, the Algal Ponds, to its end, the wetlands, creating an alternating string of shallow and deep areas (Figure 7). The module tests well against landscape design considerations: The spatial indentations of land that are created are approximately 80 feet by 22 feet. (The channel width dimension is established by the cross section calculations which follow). This is desirable as it accommodate activities such as parking, group meetings, and picnic spaces, for example. The primary calculations for the proposed channel design deal with the cross sectional design, specifically how it relates to flow. Tables 1-5 describe the entire sizing process and how the deep and shallow sections can be designed to work with the design criteria for the facility *and with one another*. In this design process I determined that some variables would be established initially and fixed for the calculations, and others would be allowed to adapt and change, in order to create consistent performance of the deep and shallow sections.

First, the fixed variables: The Design Criteria calculations provide the design flow (Table 1). I calculated the average daily flow based on the last 12 months of data (Figure 8). During the April 21, 2006 Interview, Paul Frank suggested that if I am proposing a new channel construction, I should incorporate future water needs. As such, he suggested that I design for a 10% increase in flow. The total design flow is then nearly 40 MGD. I am proposing that the new channel design be used along *both* the north edge of the wetlands and the south edge of the wetlands. This use of two channels is based on the design of the wetlands themselves: They are divided into a “North Cell” and a “South Cell” (Figure 4). Although, to the observer, they appear to be one large wetland, the whole acreage is divided to provide for control and maintenance. For example, the facility may need to drain and take “offline” one of the Cells in order to perform maintenance. Based on this information, I decided to propose two channels, one delivering water to each Cell. Each channel must then accommodate *nearly* 20 MGD, equal to 2,654,412 cubic feet. This became the fixed, target discharge.

I then defined the other fixed variables: I used the Cowan Method to determine values for n for the designed cross sections (Table 2). The other important fixed variables are the depths of the water in the deep and shallow areas, 5 feet and 1.5 feet, respectively. This depth affects the overall discharge calculation and Hydraulic Radius Calculation, which in turn affects the velocity of the water, and then also affects the discharge. Another key factor is that in order for the alternating deep and shallow sections of the channel to work together to convey water, their velocities needed to be the same. I treated this consideration as similar to a fixed variable, meaning that once the velocity for one section was established, it became fixed for the other.

The variables that I permitted to change or adapt were the width of the cross section, which affects the overall discharge calculation and Hydraulic Radius Calculation, and the slope, which affects the velocity. I began with the calculation for the deep section; the design incorporates the 5-foot depth of water as well as a velocity and area that produce the target discharge (Figure 9). Once this velocity was established, I used it as a fixed variable for the shallow cross section design (Figure 10). Considering the 1.5-foot water depth requirement, I used the fixed velocity to back-calculate for the remaining variables. In this way, I needed to balance the effects of the cross section width and the slope. A key result is that the slope for the shallow section needed to be several times greater than the deeper cross section. The shallow cross section's characteristics were then established, and each cross section produces a consistent speed and amount of flow. Once the cross sections were designed, I was able to draw the specific dimensions of the channel in plan view; I was able to incorporate the specific widths of the deep and shallow sections in the final plan drawing.

Discussion

Although I was unable to present this research at the Third Annual California Water Symposium, I sought feedback through a follow-up interview with Paul Frank (May 8, 2006). I described my data and how it led to the proposed channel, as well as my design process. An initial design solution was a

compound channel in cross section, with the deep area running the entire length of the channel, flanked by shallow areas. I learned that this would not achieve the goals of the wetland, as all water must move through both deep and shallow areas. This information is what led me to the current design proposal, which has sequential areas of shallow and deep water. I also questioned Paul about the design of the wetland itself: wouldn't the shallow sections clog with sediment? Paul addressed this issue by describing that the sediment in the waste water is unlike that of river water. It consists of organic suspended solids, not "grit" or sand. The organic suspended solids in the case of the Stockton facility are algae, which enter the flow during the previous treatment stage, aptly named the Algal Ponds. Later, during my tour of the facility, I confirmed this information while interviewing Greg White. Greg further described that the algae are consumed by the other organisms in the water, specifically benthic organisms. The sediment highlighted in Figure 6 does not substantially accumulate, as it is later consumed (May 17, 2006).

Paul Frank addressed another issue regarding the residence time of the water. The flow through the wetland is many times slower than the flow through the proposed channel. The wetland flow is specifically designed to accomplish a certain level of treatment, removal of "suspended solids, biochemical oxygen demand, and ammonia-nitrogen" (Frank, *Treatment*, 1), which faster moving water would not fully accomplish. However, he went on to say that the additional treatment potential and overall water capacity increase for the facility would be worthy of the channel design. He also suggested that the proposed channel could have another application if used as a riparian corridor: Incorporating tall, shading-creating trees throughout the length of the channel would provide a valuable opportunity to cool the water. This is especially important as "mosquitofish" are approved by vector control agencies as a strategy to prevent the growth of mosquito larvae and require the coolest water possible to survive.

Conclusion

This research demonstrates that designed channels can not only improve wetlands' ability to treat wastewater, but also facilitate recreational and educational opportunities for the community. This process requires both a quantitative and qualitative design process, in order to incorporate design criteria and integrate them with design variables. It uses hydraulic principles and equations, as well as landscape design concepts and goals. As a designer, this process has allowed me to approach design in a comprehensive and scientific way. I have applied specific data and calculations to a design exercise, to ground it in reality. The proposed channel design is specific to the case study of Stockton Regional Water Control Facility and elucidates the considerations and calculations required to accomplish it. A secondary benefit of this research is that it also may be applied to other similar wastewater treatment facilities. This is especially relevant looking to the future as more and more wetlands are being used in combination with conventional wastewater treatment.

References Cited

Frank, Paul and Stockton Regional Water Control Facility. *Treatment Wetland System Startup Period Operation*. Internal Document: 2006.

Frank, Paul. CH2M HILL. Interviews: April 21, 2006, May 8, 2006.

OMI/Thames Water. *Flow Data, Daily Averages*. Facility Records: May 2005-May 2006.

OMI/Thames Water. *Solutions for the Future of Stockton's Wastewater Needs*. Internal Publication: 2004.

OMI/Thames Water. *Stockton Regional Wastewater Control Facility Basis for Design*. Internal Publication: 2002. 12-14.

Slater, Cole. CH2M HILL. Interview: April 14, 2006.

White, Greg. OMI/Thames Water. Interviews: May 17, 2006, May 19, 2006