INCORPORATING VISUAL AESTHETICS WITHIN MUNICIPAL WASTEWATER TREATMENT WETLANDS

by

Ryan Michael Bentley

(Under the Direction of Ronald Sawhill)

ABSTRACT

The accepted model for designing treatment wetlands has emphasized the function of nutrient removal. Some treatment wetlands have attempted to incorporate greater ecological function, wildlife habitat, and human uses. Seven case studies were reviewed and the effectiveness their existing visual aesthetic was assessed. This thesis asks the following question: What aesthetic design principles maximize human use within a treatment wetland? The need for this thesis is based on the assumptions that 1) although some treatment wetlands have exhibited some success as recreational areas, full acceptance of wetland parks hasn't occurred because they have lacked critical aesthetic design principles 2) that synergistic benefits can be seen from interdisciplinary design teams that understand the wide context that wetland creation incorporates; and that 3) as communities embrace treatment wetlands, integration of multifunctional parks will become the model. A conceptual design protocol that promotes aesthetic principles was proposed and applied to the reviewed case studies.

INDEX WORDS: Aesthetics, Hydraulic efficiency, Municipal wastewater treatment, Treatment wetlands, Wetland parks

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by

RYAN MICHAEL BENTLEY

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by

RYAN MICHAEL BENTLEY

Major Professor: Ronald Sawhill

Committee: Bruce Ferguson
Gary T. Green
Doug Baughman

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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CHAPTER 1

INTRODUCTION

Treatment Wetlands

Treatment wetlands are used to remove pollutants from the water that flows through them. Other common terms for treatment wetlands include passive treatment systems, constructed wetlands or created wetlands for wastewater treatment. Since natural wetlands are powered by the sun, wind, flow of water, and nutrients within the water, they are self-sustaining and require little human interference.

Treatment wetlands are a common alternative to conventional technological wastewater treatment methods. Some of the reasons that treatment wetlands have been successful include: 1) lower construction, operational, and maintenance costs, 2) they can operate at different scales; from individual residences to multiple cities, 3) flexibility allows modifications in response to changing conditions, 4) preservation, restoration, enhancement and creation of wetlands and associated wildlife habitat, and 5) potential for creation of attractive amenities for community uses such as recreation and education (adapted from Benjamin, 1993) .

Until recently, treatment wetlands were celebrated mainly for their biological removal capacities. However, as understanding of wetland systems continues to increase, benefits originally considered ancillary are becoming expected returns. Some such advantages include biological integrity, wildlife habitat, ecosystem services, and their direct human benefits such as aesthetics and recreation. Yet little research on the direct human experiential benefits of treatment wetlands has been conducted.

The primary purpose in funding large treatment wetlands is the nutrient removal capacity provided from biological processes. However, designed environments that consider the suitability of human use can provide significant returns to individuals, the local community, and the region. In urban environments they can function as attractive recreational areas, restorative environments, and can provide or significantly increase vital green space. Treatment wetlands can also encourage environmental education, public health, and community support.

Scope of Work

To understand the current trends in our society adopting wetlands, a history of wetlands and human perceptions of wetlands is discussed. Much has been written about how people have altered and undervalued wetlands, but little research has explored current trends in our society adopting wetlands. Some favorable writings have been written as well. For example, David Henry Thoreau said, *"Redeeming a swamp . . . comes pretty near to making a world"* (Thoreau, 1962:311). There are multiple documents listing the more particular requirements and science behind the planning, site feasibility, hydrologic design, maintenance, and permitting. Consequently, the science of treatment wetlands will be discussed only in context to the restrictions and requirements they bring to proposed design changes to incorporate human use. By reviewing biological nutrient removal, a better understanding of the relationship between the added design parameters for human use and functional requirements is attempted.

Also, because both the functional and ecological science behind treatment wetlands seems to have some conflicting overlaps with existing aesthetic design norms, further conceptual consideration of all these relationship will be explored.

General aesthetic principles that apply to treatment wetlands are then reviewed. Research supporting aesthetic principles applied to treatment wetlands involves two separate subjects, namely: human (functional and aesthetic) design and design of constructed wetlands. Both subjects have been significantly examined through several studies, analysis, and research separately but common literature on the combination of the two is rare or marginal. Expert work that has touched both subjects includes, Nassuaer, Campbell and Ogden, Jim Bays, Robert France, and Elissa Rosenberg. Nassauer has been writing about the ecological aesthetic for many years (1992-present) and has written multiple articles and books on the subject. Nassauer wrote most closely about the subject in a paper discussing cultural sustainability and ecological function in metropolitan wetland restoration (Nassauer, 2004). Bays composed a chapter entitled "Principles and Applications of Wetland Park Creation" in 'Handbook of Water Sensitive Planning and Design' which would seem to be aimed right on subject, however, focused almost explicitly on the engineering of wastewater wetlands (France, 2003). Robert France, the editor of the prior book, highlighted the need for interdisciplinary cooperation in a list added as a conclusion to Bays chapter. France also wrote "Wetland Design", in which he outlined the practical basics of creating wetlands (France, 2003). Although the scope of the book is broad, he mainly addresses natural wetlands as mitigation sites. And finally Rosenberg came at the subject through “Public Works and Public Space: Rethinking the Urban Park” in the ‘Journal of Architectural Education’ by forcing the integration of public works and parks by ‘rediscovering’ our buried culture (Rosenberg, 1996). This limited number of studies suggests that very little research has been done to understand the relationship between treatment wetlands and human use.

Comparative analysis of case studies revealed the following needs and opportunities that ought to be addressed in the design and operation of treatment wetlands: 1) as part of a sustainable alternative, treatment wetlands should be as natural or authentic as possible, 2) a requirement for a wider design context to be applied in placing a treatment wetland, 3) the interaction that should occur between the design team, wastewater utility, and the community, and 4) the opportunities to integrate the wetland into a community park. Others have documented similar needs and opportunities in recreational management and in the design of urban parks and open space (Hultsman, Cottrell, & Hultsman, 1998, McHarg, 1969, Dahl & Molnar, 2003).

Most aesthetic principles can be applied universally. However separate regions produce significantly different wetland types and thus some difference in aesthetic considerations exist. For example, a northern forested bog has a very different aesthetic than a southern swamp. The area of reviewed projects are all within the Southeast, thus the principles apply most to the Southeast in context to the specific local parameters of each site.

Treatment wetlands can be large or small and built for multiple functions; however, in order to provide a large enough area to attract human users for recreational purposes, emphasis is put on larger treatment wetlands. The focus of projects and recommendations are restricted to municipal wastewater treatment plants because they provide a large amount of influent and thus allows more opportunities for manipulation of water flow and location of wetlands. For the purpose of this thesis, the terms 'municipality' or 'municipal' refer to city or county utilities that manage wastewater. Factors and considerations not covered within this thesis include, but are not limited to:

- The limits of treatment wetlands in cold climates. In colder months of northern areas in the United States, plant intake of nutrients is significantly slowed and thus treatment is stunted. Copious research done on the subject and possible solutions exist to allow treatment wetlands to function in colder climates (Kadlec & Knight, 1996; Wittgren & Maehlum, 1997).
- The use of natural wetlands for human use. Wetlands used for wastewater treatment can be created or natural. There are multiple challenges with natural wetlands such as the altered hydroperiod, thus most systems have been created.
- Use of a wetland for primary treatment. Although there are examples of treatment wetlands functioning as the sole treatment, most function as secondary or tertiary treatment. Tertiary treatment has also been referred as advanced treatment or 'polishing.'
- The use of treatment wetlands for alternate applications including: stormwater, acid mine drainage, industrial waste, landfill leachate, agricultural waste, graywater, and remedial waste. Treated effluent has also been reused in a number of applications such as agricultural irrigation, groundwater recharge,

aquaculture, horticulture, and aesthetic uses such as manmade ponds or streams.

- Options for subsurface treatment wetlands within parks. There are two forms of created treatment wetlands consisting of both surface and subsurface flow. Surface flow systems function with influent introduced at the surface that flows over sandy or peat soils. Accompanying vegetation often consists of emergent plants, floating and submerged aquatic plants, shrubs, and trees. Subsurface systems have a cell or cells with wastewater routed through and below the surface of a permeable substrate supporting emergent vegetation. Subsurface flows let out the influent below the surface, usually about 12-24 inches.
- The use of small scale or onsite treatment systems for landscape amenities, interpretation, or creation of small parks.

Methodology

A review of literature regarding constructed wetlands and municipal wastewater treatment wetlands was conducted to establish a framework for existing design parameters and alternatives. A comparative case study of several wastewater treatment wetlands was then conducted. Each of the case study wetlands were chosen for how humans uses were incorporated within the design and are located within the Southeast United States. The following were considered for case studies: Phinizy Swamp Nature Park (Augusta, Georgia), Carolina Bay Wetland (Little River, SC). Orlando Easterly Wetlands (Christmas, Florida), Viera Wetlands (Brevard County, Florida), Indian River Wetland (Indian River County, Florida), Wakodahatchee Wetlands

(Palm Beach, Florida), and Green Cay Nature Center (Palm Beach, Florida). Each case was inventoried, analyzed and interpreted with quantifying factors. A comparative analysis was performed by considering history, existing characteristics, number of annual visitors, and field observation. From field observations the existing public utilities, vegetation, flow regime, and public use were analyzed.

Aesthetic considerations were superimposed over existing design criteria of treatment wetlands to explore design ideas that are achievable within the restraints of both functional and ecological objectives. These ideas were elucidated through inductive reasoning, application of other’s design ideas, and critical thinking. A conceptual design process was then applied to the reviewed projects that lacked effective aesthetic experiences.

CHAPTER 2

HISTORY AND VIEWS OF WETLANDS

Introduction

Wetlands have played an integral part of human history. Between 1780 and 1980 the United States filled or altered an estimated 53% of the 221 million acres of wetland in the continental United States (Dahl T, 1990). This 'improved land' strategy has lead to multiple wetland related issues. Just as we manipulated wetlands early in this country's history, we continue to seek responsible means to tame, control, and harness wetlands today. As wetlands continue to be a difficult matter to reconcile within our psyches, multiple views and values have emerged.

General History of the Public's View of Wetlands

To understand the current publicly held views of wetlands, a general history of wetlands needs to be discussed. The broad subject of wetlands often induces a cacophony of emotions and perceptions. A farmer struggles with temptations to ameliorate the economic uselessness of his swamp by slightly altering the pathway of the water or slightly filling a portion of the unimpressive swamp bank. An environmental group fights the evil developer with all the legal tools they have to stop the subdivision from covering natural wetlands. More mandates are sent down from the federal government requiring greater regulation of wetlands.

Our perceptions of today's wetlands may be largely skewed by the conflict between protecting natural wetlands and an individual's land rights. The history of wetland use and how our society's values formed from them give us a good framework to understand today's battle surrounding wetlands.

In our early history, wetlands were probably the source of significant food creation (wild rice, shellfish, salt pans, fishing, and meat) and resources (reeds for building, pelts, and fresh water). At that time, wetlands were probably viewed as an essential and beneficial environment. Early Chinese culture esteemed wetland plants, the water's edge, and the contrast of rocks as an art form (France, 2003:11). The plant cover and contemplative atmosphere of these created wetlands acted as spiritual retreats.

When what became later known as the United States was discovered and developed, we began to view wetlands very differently. With early Americans' exploitive outlook on the wide expanses of land, wetlands were seen as a place of disease, bad spirits, and wasted land. Efforts to drain or alter hydrology within wetlands were early hallmarks of this country's history as farmers expanded their land and altered vast inlet shorelines for crop production. State and local governments actually facilitated the healthy expansion of productive lands by issuing bonds to landowners for approved drainage areas. These drained areas doubled in size between 1905 and 1910 and again between 1910 and 1920 (Depletion and Conservation of Natural Resources - Wetlands - fragile Ecosystems, 2008).

The early conservationists were the first group to oppose these draining projects. These consisted of hunters, sportsmen, and groups such as the Audubon Society and American Game Protective Association. As more and more land was converted, the issues of poor soil and higher costs of draining wetlands began slowing extreme conversion of wetlands.

During the Great Depression (1929-1941) government programs continued to convert wetlands to usable land as a way to support employment. Only by the 1970's did the arena of public opinion begin to swing. Mounting scientific knowledge about the benefits of wetland processes and a history of failed projects helped turn the tide. In 1972 the Federal Water Pollution Control Amendments were passed. Eventually called the Clean Water Act, the act established goals to reduce the release of toxic substances into water bodies and reduce wetland destruction. In 1977, President Jimmy Carter issued an executive order for federal agencies to minimize damage to wetlands. In 1989 the Environmental Protection Agency (EPA) set forth the goal of "no net loss" of wetlands (Broomhall & Kerns, 1997). Robert France illustrated perceptions earlier to the "not net loss" goals for wetlands when he said:

> A negative view of wetlands has persisted to recent times. About 15 years ago, I proposed a research project to a federal agency to study the fate of plant nutrients that move from uplands to adjacent wetlands. The project was funded, but the federal scientist who was my project officer had changed the word wetlands to wastelands in his description of the work. He had never encountered the word wetland before and thought I had misspelled wasteland. This same federal agency now supports research on wetlands. In Great Britain, the term wetland was not even in use as recently as a decade ago (France 2003:14).

Currently the EPA has set compensatory mitigation as the management tool for wetland development. This requires that a party that alters or destroys a wetland area must offset that loss by restoring, creating, or enhancing wetlands elsewhere. This, however, has become controversial because most restored wetlands are not achieving full ecological recovery.

Supporters of private property rights and fewer restrictions on wetland alteration are also very active today. Arguments often stem over whether wetlands have actually been created by humans or if they are connected to state waters. Our judicial system has partially reinforced the belief that human created wetlands and waters that only have a groundwater or waterfowl connection to state waters are not under federal jurisdiction. These arguments hold true especially for wetlands that have seasonal hydro periods and appear dry through parts of the year.

Ecology has focused on the functional value of wetlands to advocate for preservation and restoration of wetlands. Significant research has been put into estimating total ecosystem value in dollars. One estimate is that our *total* ecosystem provides 33 trillion dollars of ecosystem services per year with wetland services equal 14.9 trillion dollars per year (Costanza, et al., 1997). The same estimate valued each acre of swamp or floodplain at $7,910 per year (Costanza, et al., 1997). The services considered for this study included: disturbance regulation, providing drinking water, flood control, cleaning the water, fisheries, recreation, wildlife habitat, and other commercial industries such as rice, medicine and cosmetics. Although these numbers cannot be accurately quantified and are possibly inflated, they appear quite effective in improving the public's view of wetlands.

Cultural values of wetlands are significant as well. Throughout the world we have examples of cultural density centered on wetlands. Many instrumental civilizations found power through the harnessing the productivity of the water's edge. Large rivers such as the Nile, Euphrates, and Tigris were altered through dams, dykes, and canals and the fertile ground utilized for food production. There are significant cities today that built directly within wetlands such as Venice and Amsterdam. Venice, Italy was the commercial center of the historic "salt route" that was linked by wetland salt pans in the Mediterranean (Viñales, 2001).

Examples of cultural use of wetlands also exist in art. The tomb of Luxor in Egypt contains paintings of waterfowl hunting scenes with wooden boomerangs and trained cats and nets (Viñales, 2001). Painters such as Patinir, Dürer, Canaletto, Turner, and Constable favored the lake, marsh and river theme (The Ramsar Bureau, 1999). Claude Monet finished his artistic work with a series of paintings of aquatic plants in his home pond in Giverny, France. In more recent history, Harriet Beecher Stowe wrote the anti-slavery novel *Dread, A Tale of the Dismal Swamp* in 1856 by using wetlands as the backdrop (Stowe, 1856).

With all the cultural, economic, educational, and environmental benefits that wetlands have provided society, wetlands continue to be undervalued and destroyed at alarming rates. According to Zedler, due to failures of mitigation requirements, "… the Section 404 permitting process has been fostering an 80 percent net loss of wetlands"

(Turner, Redmond, & Zedler, 2001). Although there are limits to how much our society can to do repair the damage we've done to wetlands, we can value our wetlands enough to mitigate anything we destroy or alter in the future. Also, as designers find more creative ways to reintroduce our society back into rich wetland environments, our society will profit from important cultural, educational, and ecological benefits.

Views of Treatment Wetlands

The public's view of wetlands are affected by multiple issues including: historic perceptions, societal norms, exposure or visual frequency, education and interpretation of wetlands, literature, advertisements, research, and even current publicity of regulatory debate over the definition of wetlands. Obviously these different information sources can affect society's views both positively and negatively. The public view of wetlands that treat municipal waste suffers from further negative input from the association with human waste. Smardon eloquently stated,

> Can we make a silk purse out of a sow's ear? The problems are formidable. Historic values and perceptions of wetlands are fraught with negative associations and images. Recent emphasis on ecological values and multifunctional aspects has 'cleaned up' the image, but leaving wetland with wastewater risks resensitizing all the historical negative imagery. We know too little of human perception of environmental quality parameters of wetlands, especially odor, water quality, and health risk (Smardon, 1989:293).

As our society's values continue to slowly shift towards environmental responsibility, we will also continue to realize the technological benefits of wetlands. A "green revolution" has recently taken place as revealed by Wal-Mart's "sustainability" campaign (Wal-Mart - Sustainability Progress Report, 2007), the success of several car retailer' hybrids and cross-over vehicles, 'going green' campaigns, and multiple others.

Although these campaigns may be more self advertising, they do show that a major segment of our society values the environmental ideal. If the trend for our society to embrace green technology continues, environmental values may express themselves in appreciation for treatment wetlands.

The emphasis and values of scientific research for treatment wetlands have changed over time. Scientists initially recognized the advantages of biological removal of nutrients within wetlands and have continued to research this subject since the early 1950's (Campbell & Ogden, 1999). The ecological (Ewel & Odum, 1979) (Guntenspergen, 1985) and wildlife benefits (Sather, 1989; Feierabend, 1989; CH2M HILL, 1999) were then researched and focused on. Value of constructed wetlands for their recreational, aesthetic, educational, and historical qualities have only been recently recognized (Sather, 1989; Kadlec & Knight, 1996; CH2M HILL, 1999). The history of research probably correlates with how our society values wetlands.

Education affects the public perception of treatment wetlands. The principles exhibited in wetlands present a valuable location to extend our knowledge. Wetlands provide a healthy environment for helping the public understand how our society works with nature. Wetlands also provide an excellent environment to educate the public about our cultural connection to wetlands. Interpretation of wetlands is part of education and can be a successful method of adding value into an area. Interpretive signage can also be a strong cultural cue that signifies that the area is well designed and cared for. Standard educational interpretation usually includes the ecology and further description of the wildlife contained within the wetland. Other interpretation could include both historic and current cultural uses of wetlands.

Conclusion

In summary, the public's perception of wetlands has changed dramatically throughout time. As our knowledge of the science of wetlands has progressed, we have begun to adopt these once "wastelands" as beneficial technologies. If the current trend of environmental awareness and wetland appreciation continues, there will be more demand and support for public spaces that incorporate wetlands. Thoughtful design of treatment wetlands will positively influence not only our society's value of treatment wetland, but will also promote better integration of public utilities as part of the community. If the public deems wetlands as valuable assets to our environment, designers have a greater obligation to promote opportunities for the public to interface with them.

CHAPTER 3

SCIENCE OF WASTEWATER TREATMENT

Introduction

To understand the restrictions to designing treatment wetlands as it relates to human use, a general understanding of the requirements that regulate the science and technology needs to be established. Treatment wetlands have only been used for large scale municipal projects for the last 35 years. A fair amount of uncertainty in the science of wetland nutrient removal has necessitated substantial amounts of research for legitimacy and widespread acceptance. Not surprisingly, wastewater management has always utilized natural methods to breakdown and remove municipal waste from our systems.

History of Wastewater

The process of treating human waste has developed since ancient times. Simple yet effective systems of waste transport have been found in the ruins of the prehistoric cities of Crete and the ancient Assyrian cities. The Romans were well known for their water conveyance systems; storm-water sewers built then are still in service today. "Although the primary function of these was drainage, the Roman practice of dumping refuse in the streets caused significant quantities of organic matter to be carried along with the rainwater runoff. Toward the end of the Middle Ages, below-ground privy vaults and, later, cesspools were developed" (Sewage Disposal, 2007). When these containers became full, sanitation workers, affectionately referred to as “honey movers” would remove the deposit at the owner's expense. The wastes were used as fertilizer at nearby farms or were dumped into watercourses or onto vacant land. This early adaptive use of human waste is strangely similar to our current outline for wastewater treatment –concentrate the waste, collect and relocate the waste, then let natural processes finish the job.

A few centuries later, there was renewed construction of storm sewers, mostly in the form of open channels or street gutters. At first, disposing of any waste in these sewers was forbidden, but by the 19th century it was recognized that community health could be improved by discharging human waste into the storm sewers for rapid removal. Development of municipal water-supply systems and household plumbing brought about flush toilets and the beginning of modern sewer systems. Despite reservations that sanitary sewer systems wasted resources, posed health hazards, and were expensive, many cities built them; by 1910 there were about 25,000 miles of sewer lines in the United States (Sewage Disposal, 2007).

Towards the beginning of the 20th century, a few cities and certain industries began to build sewage-treatment facilities in recognition of the significant health problems from discharging sewage directly into waterways. However, because of most water was still sufficiently diluting sewage and significant economic problems existed at the time; few cities or industries actually provided any treatment.

Current Wastewater Technology

Currently the most accepted systems to manage wastewater in urban settings are wastewater treatment facilities, also known as sewer treatment plants or water reclamation facilities. They function by collecting wastewater at a central facility through a series of gravity fed pipes and pumps. The plant then treats the waste by both chemical and mechanical means. These processes can be designed multiple ways, but usually include the following: screening and sedimentation, aeration or activated sludge, denitrification, chemical precipitation, and chlorination. Treatment is divided into four major stages:

- Primary treatment physically removes large solids using grates, screens, and settling tanks. Although new and updated plants use settling tanks, this process most often utilized aerated lagoons until the 1980's and many still continue in operation today.
- Secondary treatment promotes growth of bacteria and other microbes that break down the organic wastes. These biodegradation processes also take place in streams, lakes, and oceans, but the purification systems in nature can easily be overloaded with input of too much organic waste. Secondary treatment prevents this type of pollution by degrading most of the organic matter before the water is released into the environment. Secondary treatment is most often defined as

> "attaining an average effluent quality for both five-day Biochemical Oxygen Demand (BOD_5) and Suspended Solids (SS) of 30 milligrams per liter (mg/L) in a period of 30 consecutive days, an average effluent quality of 45 mg/L for the same pollutants in a period of 7 consecutive days and 85 percent removal of the same

> pollutant in a period of 30 consecutive days" (Bastian, Shnaghan, & Thompson, 1989:271).

- In tertiary treatment, concentrations of phosphorus or nitrogen are reduced through biological or chemical processes. This process is used only where it is needed to protect the receiving waters from excess nutrients.
- Disinfection is required for both secondary and tertiary treatment facilities and kills disease-causing organisms, most commonly through chlorination.

Tertiary treatment has historically required expensive techniques, thus spurring innovative alternatives such as treatment wetlands. Treatment wetlands have most commonly replaced the tertiary treatment stage of the process by receiving the effluent from secondary treatment. The word effluent comes for Latin 'effluere' –to flow out. However, the science and technology of wastewater continues to develop. Although current trends in municipal wastewater technology advance, they probably won't beable to overcome the economic benefits that treatment wetlands provide.

A recent study researched the associated costs related to tertiary treatment for both new wastewater plants and for adaptive additions to existing facilities (Jiang, Beck, Cummings, Rowles, & Russell, 2005). This study found that specific nutrient removal objectives for individual nutrients such as phosphorus create higher costs. Although not comparing wetlands, the study confirms that the efficiencies of new technologies such as membrane filtration continue to reduce costs and become more competitive with relatively high filtration results.

The traditional mechanical or chemical method of tertiary wastewater treatment may continue to be easier to pursue because it may be easier to design and build because of familiarity and economies of scale. However, if reasonably priced and suitable land is available, the cost of a constructed wetland is almost always lower. Regulations also play a role in the type of treatment chosen. Since the science and technology of treatment wetlands are constantly advancing, regulations also need to continue adapting to these changes.

History of Treatment Wetlands

The natural processes that have been harnessed and manipulated into modern wastewater treatment technology have been fin-tuned for many years. Only in the last 50 years has this technology been applied to wetlands. An early intentional use of wetlands in the United States was in Lexington, MA, which began discharging municipal waste into a large natural wetland in 1912. The first scientific pilot-scale constructed wetland was built in Germany in the early 1950s. The project was conducted at the Max Planck Institute under Kathe Seidel. She tested chemical pollutant breakdown and found that bulrush had ability to remove phenols, pathogenic bacteria, and other pollutants (Campbell & Ogden, 1999). Edward Furia, a city planner and attorney in Philadelphia, and Joachim Tourbier brought Seidel from Germany as a consultant for a wetland polishing system for wastewater. The University of Pennsylvania subsequently held the 1st international conference on biological wastewater treatment alternatives and created *Biological Control of Water Pollution;* published in 1975 by University of Pennsylvania Press (Kadlec & Knight, 1996).

Howard T. Odum and A.C. Chestnut followed Kathe Seidel with studies in North Carolina investigating the capacity of coastal lagoons to recycle and reuse municipal wastewater. After Odum finished the fifth year study, he began work in Gainsville, FL researching the effectiveness of natural cypress wetlands for municipal wastewater recycling. Wisconsin-Oshkosh professors W.E. Sloey, C.W. Fetter, and F.L. Spangler developed pilot-scale facilities to test replacing septic tank drain fields with artificial marsh treatment systems (Kadlec & Knight, 1996). About the same time Odum began working in Florida, Robert Kadlec began exploring the effectiveness of wetlands treating wastewater in cold climates in 1973. Other studies in Listowel, Ontario built and monitored five marsh systems to mainly test cold weather pollutant removal in 1979. The authors found that under ice and increased flow, cattails were shown to remove at a decreased but acceptable rate (Kadlec & Knight, 1996). The subsequent years have produced a multitude of research that addresses contaminant removal, plant uptake efficiencies, residence time requirements, and hydraulic efficiency.

Treatment wetlands have been employed in a multitude of places and situations. The first intentionally engineered constructed wetland treatment system in North America was built in Brookhaven National Laboratory near Brookhaven, New York in 1973. The system was constructed with a meadow, marsh, and a pond functioning as a series of filtrators. Just before the previous system was built, Bellaire, MI started discharging stabilized municipal wastewater into a forested wetland. The first industrial wastewater wetland treatment systems were built in North Dakota at Amoco Oil Company’s Mandan Refinery in 1975. The first large scale municipal wastewater treatment wetland was created in Houghton Lake, MI. The early success of these systems led to creation of systems all through the United States. Although there is no current accurate estimate of treatment systems, there are probably 10,000's of systems in place today. In the southeast region, Florida has the most and largest municipal wastewater treatment facilities such as the Easterly Orlando Wetland and the Lakeland Wetland. In Georgia, examples of municipal wastewater treatment wetlands include the Phinizy Swamp in Augusta, the Panhandle wetlands in Clayton County, the City of Gordon, and the City of Richmond Hill.

Constructed wetlands for wastewater treatment have evolved substantially over the last 40 years. Early treatment wetlands relied heavily on natural processes but had high failure rates. The technology continued to increase and now relies more heavily on the engineers to design and harness natural ecological functions.

Science of Treatment Wetlands

The physical and chemical environment of a wetland affects all biological processes. The most important abiotic factors are temperature, dissolved oxygen (DO), and hydrogen ion concentration (pH). The temperature of wetlands is important for internal biochemical processes, such as the nitrogen breakdown process by microbes. Diurnal cycles amplify temperature shifts for shallow surface flow wetlands more than subsurface flow systems. Oxygen is usually a limiting factor for the growth of plants and animals in wetlands. Dissolved oxygen content (oxygen dissolved in water) is affected by temperature, dissolved salts, and biological activity. The amount of dissolved oxygen in the water increases as temperature decreases. As dissolved oxygen is taken up by plants and microbial processes, dissolved oxygen decreases.

The pH affects the solubility of many gases and solids. As plants actively photosynthesize and take in carbon dioxide, the pH of water rises as carbonic acid is removed from the water. Because respiration decreases water pH, when respiration surpasses photosynthesis the water pH decreases. Some chemical reactions are controlled by pH and can be permanently restricted causing particular chemicals to eventually build up within the soil structure of the wetland. Because treatment wetlands constantly have relatively nutrient rich influent the pH is important to control.

Treatment wetlands have the following functional capabilities: 1) sedimentation of suspended solids, 2) digestion and removal of biological oxygen demand (BOD), 3) removal and recycling of nutrients (primarily nitrogen and phosphorus), 4) precipitation of metals, 5) removal of pathogens, and 6) degradation of toxic compounds.

Sedimentation or reduction of total suspended solids (TSS) results mostly from low water velocities caused by slow water movement induced by the presence of vegetation and underlying gravel. The concentration of total suspended solids is measured by filtering, drying and weighing the material. Turbidity, or the measurement of suspended particles in the water, is primarily caused by suspended solids and can be used as a surrogate measurement for TSS.

Digestion and removal of biological oxygen demand (BOD) in treatment wetlands is accomplished by plant uptake. Biological oxygen demand is actually a measurement of carbon in the water column. Biological oxygen $demand_5$ is determined by taking an air tight water sample and measuring the amount of oxygen depletion at the end of five days. For cleaner water, longer periods of time can be used. For example, BOD_{30} would be a measurement of oxygen after thirty days. Most microorganisms consume oxygen (O_2) to break organic carbon into carbon dioxide (CO_2). Biological oxygen demand is important because high levels of organic matter in the water column can result in oxygen depletion in the water and harm or suppress surrounding aquatic life. Treatment wetlands are very effective at removing organic compounds in the water through microbial and plant processes that release both carbon dioxide and methane (CH_4) into the atmosphere. Wetlands store large amounts of carbon in plant material and peat. During seasons that plants are not growing, large amounts of decomposition can create a net export of carbon.

Nutrient removal and recycling in treatment wetlands is primarily a soil and plant process. The two main nutrients of concern are nitrogen and phosphorus. Nitrogen can be harmful to humans in drinking water (methemoglovinemia, or “blue baby” syndrome, in infants), un-ionized ammonia is potentially toxic to aquatic organisms, and elevated nitrogen concentrations can cause eutrophication (Campbell & Ogden, 1999).

Nitrogen enters wastewater flow in both organic and inorganic forms. A significant portion of nitrogen is introduced as ammonia. An ionized form (NH^{+}_{4}) and an un-ionized form (NH_3) of ammonia exists in normal water settings. Under normal pH and temperatures, the ionized form is dominant with pH being the more controlling factor. As the pH increases and the temperature decreases the un-ionized form becomes more dominant with the balance point being just above a pH of 8. The un-ionized form is more volatile and thus breaks down more rapidly. In both its forms ammonia is the preferred nutrient form of nitrogen for most wetland plant species and autotrophic bacteria species because it is chemically reduced and therefore can be readily oxidized in water. Urea and uric acid are other ammonia additions to the water column. Uric acid is from mammal excretion of ammonia with an addition of carbon dioxide to decrease its toxicity.

Other forms of nitrogen in treatment wetlands include nitrite, various nitrogen gases, and organic nitrogen. Nitrite is an intermediate oxidation state of nitrogen between ammonia and nitrate is not chemically stable. Nitrate is another essential nutrient for plant growth but in excess can cause eutrophication. Gaseous nitrogen may contain more than just nitrogen (N_2) and nitrous oxide (N_2O) such as nitric oxide or ammonia. Organic nitrogen consists mainly of amino acids as components of proteins. One to seven percent of all plants and animals dry weight are made up of nitrogen primarily though amino acids (Kadlec & Knight, 1996).

Peaty sediments typically have one to three percent nitrogen. Plants usually store one to four percent nitrogen. There is a large variation between different plants and even different plant parts. Due to trees having larger mass, forested wetlands typically have two times or more concentrations of nitrogen than emergent marshes (Kadlec & Knight, 1996). These concentrations affect overall nitrogen storage calculations in design.

Ammonification or mineralization is the biological transformation of organic nitrogen to ammonia. The process is primarily mediated through microbial breakdown of plant tissues that contain amino acids. This process occurs more rapidly than nitrification thus it is a major design consideration. Ammonificiation increases under flooded conditions and as the temperature increases with an optimum temperature of 40-60C (Kadlec & Knight, 1996).

Nitrification is the principal transformation mechanism that reduces the concentration of ammonia nitrogen to nitrates. It is a two step microbally mediated aerobic process as bacteria use oxygen as a receptor during the transformation. The first step is mediated by nitrosomonos bacteria that break down ammonia (NH_3) to nitrate(NO_3-). Nitrobacter bacteria then break down nitrate into nitrite (NO_2). The overall process transfers ammonia and oxygen into nitrate, hydrogen, and water. The limiting factors are amount of nitrosomonos bacteria, ammonia nitrogen, temperature, pH, and dissolved oxygen.

Denitrification is an anaerobic (little or no oxygen) two step process where nitrates or nitrites are transformed into nitric oxide (NO), nitrious oxide (N_20) and finally nitrogen gas (N_2) by heterotrophic metabolism. Denitrification is an anaerobic process because oxygen presents a better source of energy than nitrogen as a final electron acceptor; therefore, all available oxygen must be consumed before denitrification can occur. The primary bacteria responsible for denitrification are pseudomonos that break down nitrite to nitrogen gas. Denitrifying bacteria are more prevalent than nitrifying bacteria and are also more prevalent in developed treatment wetlands than in natural wetlands. Some nitrites can be taken up by plants (up to 20% of total nitrogen uptake) but nitrites are less preferred than ammonia (Kadlec & Knight, 1996:406). Nitrogen is removed from the water column through a settling of N-containing particulate matter, plant consumption, and bacteria denitrifiers breaking it down into nitrogen gas which then exits the system through the atmosphere.

Pretreatment of wastewater also constitutes an important factor in ammonia breakdown within treatment wetlands. Aerated lagoon systems are preferred within a treatment wetland system because aerated lagoon systems produce nitrogen primarily in the form of nitrates. Another alternative is anaerobic pretreatment but this leaves more ammonia in the wastewater (Kadlec & Knight, 1996).

Significant amounts of phosphorus can also enter treatment wetlands after primary treatment. Phosphorus can be a long term problem because there is no metabolic pathway for removal, thus it must be physically removed or sequestered. When phosphorus is a major contaminant of concern, plant or soil harvesting can be performed. Phosphorus can be taken up by plant consumption, absorbed by periphyton (substrata attached algae and microbes) or by soil absorption. Available phosphorus may be significantly reduced during initial plant growth but usually levels off after the first few years. Phosphorus tends to absorb well to positively charged edges of clay particles. After phosphorus is absorbed by particles and then buried, it turns into peat. Peat forms mostly in northern areas because the rate of biomass production exceeds the rate of anaerobic digestion; thus in southern areas, treatment wetlands are not as effective at long-term storage of phosphorus. Permanent storage of phosphorus should typically be about 0.5 grams per meter squared per year (Nicols, 1983).

Many metals in small concentrations are required for plant and animal growth. Other metals, such as cadmium, mercury and lead have no biological benefit and are toxic at even low concentrations. Wetlands treat these metals through plant consumption, soil adsorption (binding of soil particles), and precipitation (formation of solid compounds). Rates of metal consumption vary by plant. Wetlands become effective sinks, or holding points for most metals due to these processes. When metals undergo adsorption or precipitation they usually become insoluble and stay within the wetland soil structure unless disturbed or moved. Although not studied in full, existing data support strong removal capacities for most heavy metals (Campbell & Ogden, 1999).

Removal of human pathogens is another critical factor. Human pathogens are usually present in untreated domestic wastewaters. Pathogens consist of viruses, bacteria, fungi, protozoans, and helminths. Because of the difficulty of measuring all pathogens, an indicator species of coliform bacteria has been chosen resulting in the term fecal coliform (Kadlec & Knight, 1996). Wastewater presents a hostile environment to pathogenic organisms through factors such as natural die-off, temperature, ultraviolet light, unfavorable water chemistry, predation, and sedimentation. The main mechanisms within wetlands to treat pathogens are not clear. Research has shown that longer residence time (natural die-off) and the existence of plant material help treat pathogens. Treatment wetlands are usually about 95% effective in removing fecal coliform (Kadlec & Knight, 1996).

Conventional treatment methods employ the following disinfection processes: chlorination, ozonation and ultraviolet disinfection. Chlorination is known to be toxic to some aquatic life and can bond with other organic compounds to become carcinogenic.

Ozonation is a treatment process that destroys bacteria and other microorganisms through an infusion of ozone gas. Ultraviolet disinfection is more expensive but treats viruses most effectively (Hammer, 1989).

Some compounds that enter wastewater are degradation-resistant. These usually constitute toxic natural or man-made organic compounds. The main process of removal is adsorption. Other processes, such as microbial degradation, volatilization, and photochemical degradation can break down some chemicals. Data is still relatively limited with these compounds (Kadlec & Knight, 1996).

Phytoremediation

Phytoremediation is the use of vascular plants, algae and fungi to remove and control wastes or spur waste breakdown by microorganisms in the rhizosphere. Plants remove and control wastes in many ways. The following terms define the pathways of contaminant modification:

- Phytoextraction is the uptake and concentration of substances from the environment into the plant biomass.
- Phytotransformation is the chemical modification of a substance through plant metabolism. Phytodegradation and phytostabilization are both results of phytotransformation.
- Phytodegradation is the partial breakdown of a compound through plant metabolism.
- Phytostabilization is the plant ability to immobilize (or somewhat reduce mobility) a substance in the environment.

- Phytovolatilization is the removal of a contaminant into the atmosphere through the leaf structure (McCutcheon & Schnoor, 2003).

The other part of phytoremediation is the role the plant has in enhancing soil microbial activity. Hydrophytic vegetation has adapted to low oxygen conditions in the root zone through several methods. One main strategy is the formation of aerenchyma. These are small void spaces within the stem of the plants that allow oxygen to be carried down into the root zone. The oxygenated area around the roots is called the rhizosphere. As the rhizopshere becomes oxygenated several bacterial processes are allowed to take place. Bacterial concentrations in these areas can be 100 times greater than in the overall soil composition (Batzer & Sharitz, 2006). These microbial processes fostered by added oxygen, carbon, and other nutrients often spur greater breakdown of environmental pollutants (rhizodegradation). These root areas also filter and absorb many metals from the water column resulting in rhizofiltration.

Phytoremediation is mostly solar driven. Bioremediation is remediation exclusively based on heterotrophic microorganisms (organic consumers). Wetlands also provide anaerobic and aerobic conditions which facilitate some xenobiotic (foreign compound to living organisms) transformations, stabilize organic pollutants and metals, and irreversibly bind microbial and phytotransformation products and metals (McCutcheon & Schnoor, 2003).

Conclusion

Being familiar with the science of wastewater treatment wetlands helps understand the tolerances available to implement other design objectives within a project. Nutrient uptake rates and plant nutrient loss in the fall have crucial implications on the maintenance and access requirements to a treatment wetland. Since the plants create the working foundation for treatment wetlands, understanding then science of nutrient removal can prevent design decisions that impede the processes that create value for the wetland.

CHAPTER 4

EXISTING FUNCTIONAL DESIGN PRINCIPLES

Introduction

> *By treating large amounts of sewage with settling lagoons and constructed wetlands, 75 to 95% of energy costs can be saved, as compared with using traditional concrete, steel, and energy-intensive sewage treatment plants. Installation costs of a constructed wetland sewage treatment system are usually 20 to 30% less than those of tradition sewage treatment facilities, and management needs will be 50 to 75% less* (Lyle, 1996:295).

Treatment wetlands provide a cost effective alternative to traditional wastewater treatment methods. The basic design and construction methods for building treatment wetlands have been studied and implemented successfully for many years. Although the exact engineering for these systems can be complicated, the concepts for designing treatment wetlands are fairly basic.

Hydrology and Sizing

Wetland hydraulic capacity is defined as the ability of a wetland to process a given volume of water in a given time. Hydraulic residence time is the time it takes for a molecule of water to travel from the inlet of the wetland to the outlet. Because constructed wetlands are usually designed for uniform distribution of influent over the wetland, the hydraulic residence time can be calculated with a fair amount of accuracy. Uniform distribution or hydraulic efficiency more specifically refers to the efficiency of the water flow through the wetland to get maximum interface with the sediment and plant material for nutrient removal. Several factors affect this including the shape of the wetlands. If the shape is long and narrow, the water has less opportunity to create preferential flow paths. There are other alternatives which help with both the flow paths and velocity such as creating perpendicular ditches on the bottom of the ponds, using perforated pipes at the point of influent introduction, constructing baffles, and using manifold delivery systems.

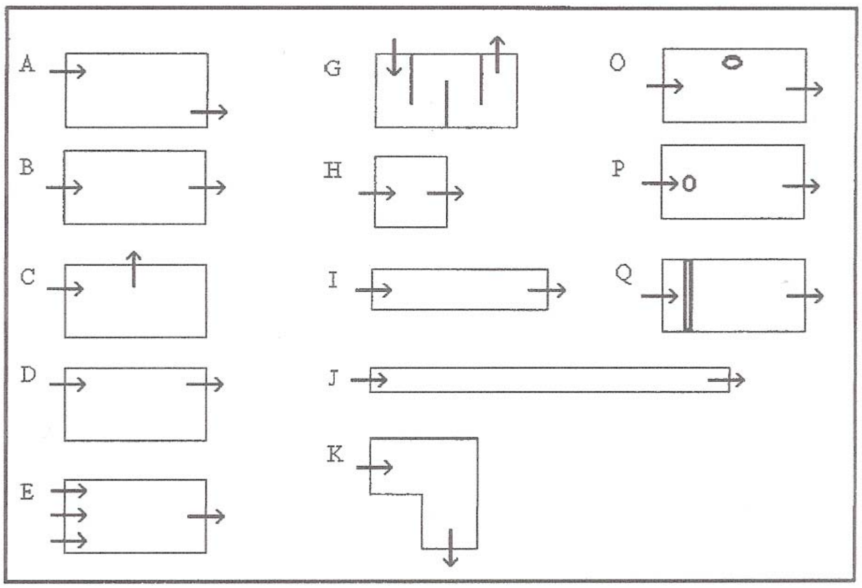

Figure 4.1 – Perrson's Investigated Thirteen Pond Shapes and Configurations

(Perrson, Somes, & Wong 1999)

Table 4.1 – Perrson's Ranking of hypothetical ponds According to λ

(Perrson, Somes, & Wong 1999)

Category	Cases
Poor Hydraulic Efficiency	A, B, C, D, I, H, K & O
Satisfactory Hydraulic Efficiency	P & Q
Good Hydraulic Efficiency	E, G, & J

Water distribution is important because it has a direct affect on nutrient removal. Persson, Somes, and Wong (1999) studied hydraulic efficiency for thirteen different shapes of created wetlands. The conclusion from their research is that the most effective shapes for treatment wetlands are rectilinear forms that incorporate a catalyst such as baffles to help distribute the water evenly.

Normal water depths of wetland cells are generally recommended to be 12-30 inches deep for surface treatment wetlands. The most efficient constituent removal takes place at twelve inches. However, as the depth is increased, cost goes down by effectively decreasing the required surface area. Cells with less width better maintain even flow patterns without preferred pathways. Banks and vegetation help uniform flow by dissipating the velocity through the friction. Patchy open water bodies often have greater velocity and can inhibit vegetation due to less bank area.

Although there are approximate calculations for sizing wetlands, there are many factors that eventually determine the size. These include treatment goals, (designing for effluent of BOD_{30} compared to BOD_{10} doubles size), detention time, terrain, and local climate (wetlands are a temperature-sensitive technology) (Kadlec & Knight, 1996). The most important factor is probably amount of flow.

Since the detailed work of sizing a wetland can be formidable, the basic solution is to find the right retention time. The average retention time is between 12 to 15 days. After this factor has been established, the calculation consists of simply providing enough volume in the wetland cells to accommodate the maximum wastewater per day multiplied by the retention time.

For example, the Easterly Orlando Wetlands incorporate about 1200 acres to treat an average of 20 million gallons per day. The equation to find the total square feet required holding the total gallons per day would be IxR/D/7.48 gal/ft^3 where I is influent, R is calculated retention time, and D is depth. Therefore:

20 million gallons per day x 15 days = 300 million gallons

300 million gallons / 7.48 gallons per ft^3 = 40,106,951.87 ft^3

If the average depth of the wetland was 12 inches then we would divide:

40,106,951.87ft^3 by 1 foot and get 40,106,951.87 ft^2.

With this many square feet, more than one cell would be required; however, the full square area of wetland would be the square root of 40,106,951.87 ft^2 which would be approximately 6333 feet by 6333 feet. This equates to 921 full acres of wetland, an additional 10%, or 90 acres would normally be added as buffer for a total of about 1010 acres. After the addition of berms, access roads, amenities and preserved forests of about 190 acres, the total comes to about 1200 acres. The land usage comes out to be about 7-15% auxiliary structures and facilities and about 85-93% total wetlands.

Within constructed treatment wetlands, berms are installed to help move the wastewater in a controlled way throughout the wetland. Berms often function as accessible paths for maintenance equipment. The berms are usually around four to eight feet high and divide the wetlands into individual cells. Berm height is based on overall average cell depth plus built in storage for stormwater within the cell, and then another few feet of freeboard to protect the stability of the berm. Berms designed for maintenance equipment usually add more freeboard. The average berm slopes are 30%. The slope steepness and overall berm height determines the width at the base of the berms.

Another consideration is the depth and flow of water to facilitate the breakdown of nutrients, primarily nitrogen. For ammonia to be converted and released as nitrogen gas, both aerobic and anaerobic conditions must occur. Shallow areas, usually 6" deep will allow oxygen to penetrate through the water column and elevate the dissolved oxygen in those areas. Deeper zones, (24"+) are considered mostly anaerobic because oxygen isn't getting to the subsurface through the water column.

> Deep zones are often incorporated into constructed wetlands to distribute the flow laterally, provide refugee for fish and other wildlife in dry weather, increase wetland volume and thereby residence time, provide quiescent areas to enhance the settling of suspended solids, contribute to the passive aeration of the water column, and furnish anaerobic environments for denitrifying bacteria (Lightbody, Nepf, & Bays, 2007).

A common design practice is to design the first stages of treatment with shallow cells, thus mediating ammonia breakdown to nitrate. After this process, deep zones are designed for anaerobic activity and mixing to occur. As anaerobic activity occurs, some nitrates are able to complete the breakdown process into nitrogen gas. Because of the anaerobic conditions, sulfuric breakdown is also occurring and can create the familiar salt marsh ‘rotten-egg’ smell. For this reason, deep areas are usually situated central to large cells and distanced from any human access points.

Anoxia is achieved primarily through lower velocity. Flow rates below 0.4 cm s^{-1} create an oxygen depleted environment similar to that of stationary water (Gosselink & Turner, 1978:70). Flow rates of about 1 cm s^{-1} allow sufficient agitation of the water column to be saturated with oxygen. Some scientists have assumed that all areas of a wetland are aerobic due to oxygen released from plant roots and below water stems. Plants do release low levels of oxygen through their roots into the rhizosphere but this amount may be negligible because plants within treatment wetlands require more oxygen to cope with higher nutrient loads (United States Environmental Protection Agency, 2000:16).

Physical Components and Costs

“Created treatment wetlands typically cost about $5,000-$6,000 per acre to build, an investment that is between ten to fifty percent of the costs of conventional chemical treatment facilities, with only about half the costs associated with long-term operation and maintenance” (France, 2003:17). Overall costs for constructed wetlands can be broken down into excavation, gravel, liner, plants, distribution and control structures, and fencing. As a general rule, gravel is 40-50% of total cost and liners are about 15-20% of the total costs. Liners are not required when the permit allows water to recharge groundwater or if the subsurface soil contains a significant clay layer. The costs of verifying the soil content is most often more expensive than a liner (Campbell & Ogden, 1999).

Detention time has proven to be the most effective cost comparative tool because it takes into account the size, depth, media, and amount of plant material. Additional factors affecting cost include media type (deeper systems require less liner), pretreatment type, number of cells (more cells require more hydraulic control structures and liners), and source and availability of gravel media.

Vegetation

Wetland vegetation within treatment wetlands includes a multitude of plant types. Most plants can be categorized into three vegetation types. Submergent plants grow completely below the water surface. Emergent plants are rooted in the soil but send stems and leaves above the water. Floating plants float on the water surface with roots solely in the water column.

Although all plant types have various nutrient storage capacities, most constructed wetlands focus on emergent plant types due to their deep root structure and large plant mass. "There is no evidence that treatment performance is superior or different among the common emergent wetland species used in treatment wetlands" (Kadlec & Knight, 1996:633). The deep root structure allows for better contact area for microbial bacteria and rapid plant growth and infilling. Emergents are also preferred for their adaptability and local presence. It should be noted that although emergent vegetation is mostly used, submergent and floating vegetation types add diversity and depth in ecology and wildlife habitat.

Three primary emergent plants are used in treatment wetland applications. The particular plants are used because of their hearty growth, rooting habits and widespread availability. Cattails (*typha* spp.) grow throughout the United States; they are vigorous growers and grow in a diversity of environments. Their roots normally extend only to 12 inches and can be propagated easily. Their propensity to spread can pose problems to adjacent natural wetlands (Campbell & Ogden, 1999).

Bulrushes (*Scripus* spp.) also grow throughout the United States but also inhabit coastal waters. Bulrushes are less vigorous growers but tolerate higher pH and remove nitrogen more efficiently. Their roots can penetrate up to three feet or greater and are commonly used for subsurface flow systems. Due to their deeper root zone they can tolerate more fluctuations in water depth. Common reeds (*Phragmites australis*) offer a more ornamental look as an annual grass. Their height ranges from 6 to 12 feet with roots penetrating up to 18 inches. Common reeds are very effective in transferring oxygen to the root zone as well (Campbell & Ogden, 1999).

In Georgia there has been substantial enthusiasm over the 'Restorer' Bulrush hybrid (*Scipus californicus*) released by the USDA-NRCS Jimmy Carter Plant Materials Center in Americus, Georgia. This plant is known to be deep rooting, large, winter hardy and particularly efficient at extracting certain metals such as copper and mercury. Other plants particular to Georgia are listed in Table 4.2.

Table 4.2 – Effective Treatment Wetland Plants for Georgia

(Surrency & Owsley, 2003)

Canna lily, Red and Yellow	*Canna* spp.
'Sumter Orange' Daylily	*Hemerocallis fulva*
Elephant ear, Taro	*Colacasia esculenta*
Iris, Blue Flag	*Iris versicolor*
Iris, Louisiana	*Iris hexagona*
Iris, Yellow Flag	*Iris pseudocornus*
Umbrella Palm	*Cyperus alternifolius*
Woolgrass	*Scirpus cyperinus*
Thalia Powdery	*Thalia dealbata*
Pickerelweed	*Pondetaria cordata*

Regulations and Permitting

The regulatory process for treatment wetlands can be time consuming and tedious. There are often several permits and jurisdictions involved. The Clean Water Act Section 404, otherwise known as the National Pollution Discharge Elimination System, is always required for discharges into regulated waters. This permit is issued under state jurisdiction for five years and then must be renewed. Under this permit the criteria for contaminant and nutrient removal are set. When a wastewater treatment plant is planned, the state agency runs a model that predicts the allowable contaminant load for the effluent by entering the local hydrology and estimated wastewater volume. The wastewater treatment plant is then required to sample the effluent from the plant and meet the standard determined from the model. Constructed wetlands take some time to establish due to plant growth. Sometimes the permit criteria can be extended to account for this growth period.

The Clean Water Act Section 404 is only required if any fill activities were planned for existing wetlands. The United States Environmental Protection Agency is currently evaluating the concept of allowing some treatment wetlands to also act as mitigation wetlands. If this were the case, then the constructed wetlands would be subject to regulation under Section 404. Environmental Protection Agency recommends that humans have no contact with wetlands being used to treat municipal wastewater to meet primary or secondary treatment standards (The Interstate Technology & Regulatory Council Wetlands Team, 2003). Although most municipal wastewater treatment projects provide tertiary treatment and do not fall under the EPA's recommendations for no human contact, most designs have restricted human access to the water itself. Most designers have considered the berms slopes as satisfactory measures to restrict contact. Yet due to safety, some sites, such as the Green Cay Wetlands, have only allowed access to the wetlands through boardwalks even though the site provides tertiary treatment.

Conclusion

Current design standards and construction methods for the creation of treatment wetlands have been well established. Minor alterations of the hydrology, components, and vegetation can often greatly benefit the human experience. Regulatory agencies play a decisive role in the future of human use within treatment wetlands. The degree of regulations imposed for safety within wastewater treatment wetlands drastically affects the latitude of design opportunities for human use. Understanding the basic requirements that make treatment wetlands work allows a wider understanding of what changes can be made to a treatment wetland to allow human use within it.

CHAPTER 5

AESTHETIC DESIGN PRINCIPLES

Introduction

The definition of aesthetics pertains to the appreciation of beauty or something that is visually pleasing. A more scientific definition would include the study of the mind and emotions in relation to the sense of beauty (Aesthetics - Definitions from Dictionary.com, 2008) or visual quality, a measure of the overall impression or appeal of an area as determined by the particular landscape characteristics such as landforms, rock forms, water features and vegetation patterns, as well as associated public values. The attributes of variety, vividness, coherence, uniqueness, harmony, and pattern contribute to the visual quality classifications of indistinctive (low), common (moderate), and distinctive (high). Aesthetics are studied as a point of reference to assess whether a given project would appear compatible with the established features of the setting or would contrast noticeably and unfavorably with them (Visual Resources/Aesthetics, 2004).

Quality depends on *both* features of the landscape and the perceptual/ experiential processes those features evoke in the human viewer.

> Aesthetic experiences are fundamentally triggered by affective (emotionally- based) processes, which are shaped by evolved biochemical, physiological, and psychological capacities and predispositions. The complexity of human perceptual response also suggests that knowledge and cognitive processes can change perceptions. Learning to recognize habitats, for example, could influence

> people's intentions for landscape change (Gobster, Nassauer, Daniel, & Fry, 2007).

Thus environmental influences or learned values affect the perspective of the person viewing the landscape. People can react to landscapes very differently based on multiple factors including: gender, race, life-stage (age), education, socio-economic background, and familiarity (Lyons, 1983). Although some part of the evaluation is based on the 'eye of the beholder', research has shown that some important physical design principles can be elucidated from the multiple factors that influence viewer's perceptions of the landscape. Much of these principles have been extracted from visual preference surveys.

Daniels further points out that our philosophy of landscape aesthetics comes from two competing viewpoints: the expert, which comes from principal based training and most greatly influences the environmental management and regulatory decisions, and the perceptual based approach, which relies on public input (Daniels, 2001). The publics' input is crucial to consider and incorporate within the design because a spectrum of reactions may exist within one landscape. Also, expert views often allow biased view and objectives to dominate the decision process. Carlson has attacked the sole reliance on the expert (1990).

Not surprisingly, with disagreement amongst those who define the structure of aesthetics, there are major challenges associated with applying aesthetic principles. This is especially true for naturalistic or ecologically valued systems. Treatment wetlands are inherently ecological landscapes, or landscapes that are valued for their ecologic value. Theoretic views on aesthetics and ecology, or the ecological aesthetic, are prolific. Ecological landscapes present challenges to aesthetics because there is less human control of these landscapes. Also, “constructed wetlands may fail to meet cultural expectations for attractive landscapes” (Nassauer, 1997:756). However, the success of some treatment wetlands to attract groups of people has been proven through numerous projects such as the Arcata Marsh, Wakodahatchee Wetlands, and the Green Cay Nature Center (See Chapter 9). “In a world dominated by humans, landscapes that are perceived as attractive are more likely to be sustained over time by human behavior” (Nassauer, 1997:756).

Aesthetic Issues

Mozingo also notes the common negative public reaction to ecologically valuable landscapes (1997:48). Mozingo offers the following issues as “realms of contention” and discusses solutions to each. The five issues are visibility, temporality, reiterated form, expression, and metaphor.

The issue of visibility is evident especially within natural landscapes. Manipulated landscapes often rely on specific pathways or view sheds to create sequenced or orderly frames to stimulate feelings or heighten the experience. Natural landscapes often blend in or neutralize views. Nassauer states that such ecological landscapes are not “set up for viewing” (Nassauer,1995). Because of heavy manipulation of vegetation and creation of large open water bodies within treatment wetlands, the issue is slightly muted. However, the creation of effective views is still pertinent.

Ecological landscapes constantly change; thus temporality becomes an important topic to consider. The major elements of ecological landscapes are comprised of vegetation –living, growing and changing plants. As seasons change, colors and vibrancy may be lost. Visually enclosed areas can be opened up after the loss of leaf barriers. In more urban landscapes, many designers have minimized the use of vegetation due to less control over visual changes (Spirn, 1984). However, the changes themselves can elicit interest. People are drawn to the blooming flowers of the spring, the changing leaf color of the fall, and overall landscape growth. Interactions with wildlife, the change of seasons, and weather also generate human appeal.

Reiterated forms may be seen as a vernacular of forms, shapes, and textures that create cohesiveness, comprehension, and structure. Natural wetlands provide rare environments that are easy to understand or comprehend. While cypress tree trunks in forested wetland may form a framework of cohesiveness, thick multidirectional branches, shrubs, vines and other vegetation work against it.

The structured form of treatment wetland berms begins to create a recognizable framework which people can use to make sense of the landscape. This recognizable earth form works by creating an understandable landscape but can fail in creating interest. Berms effectively break up the landscape into regions but may lack enough structure to create well defined spaces. Emergent plantings, tree groves, and built structures all aid in creating forms that are recognizable and begin to structure the ecological environment.

Mozingo characterizes expression as the aesthetic emotions and feelings that come from controlled landscapes such as gardens, sculpture, or art. Obviously the challenges to introduce such expression within wetlands can be formidable; yet, the landscape and especially the interactions of wildlife within it can create environments that impart such emotions. Controlled entrance areas present opportunities for artistic and educational expression. Other interpretive areas or stations can introduce opportunities as well.

The last topic Mozingo discusses is metaphor, bringing depth, symbolism, or vision to a landscape. In other words, ecological landscapes most often represent the ecologic function they perform. Mozingo states that ecological design most often ". . . is the thing. What remains is an empirical product which then removes any desirability of elevated, or beyond-the-self, perception. It is plagued by dreary utility –it denies the opportunity of cultural connection and reflection" (Mozingo, 1997:56). Since treatment wetlands can be dreary and utilitarian, incorporating cultural elements that ties human activities in with the nutrient cycle should be emphasized in such systems.

Joan Nassauer studied comparative aesthetics among wetlands and emphasizes cultural cues, or objects that denote control or familiarity. Nassauer found that strong cultural cues encourage acceptance from the community and adjacent landowners of the area (Nassauer, 2004). These cultural cues include adequate signage, attention to vistas and views near open water bodies, wildflowers with strong colors and mown or "kempt" areas (perceived care and security) near the human experience. Others have suggested limiting plant diversity near major paths to suggest order. Cultural cues may also include human structures such as boardwalks, benches, view platforms, signage as well as the presences of green manicured berms, rolling terrain, open water and wildlife.

Another aesthetic issue is perceived motion within the landscape. Anne Spirn writes, "…an aesthetic celebrates motion, change, and encompasses dynamic processes, rather than static objects" (1984:108). Views into and out of the open void space can create the motion and change our experience of the place.

Curves are often used in natural landscapes due to the natural incline or decline of the land. The long linear forms, open views and symmetry typical of treatment wetlands can be an attractive design form. However, linear forms are a means of showing control and common within urban and architectural designs. Relating to natural landscapes, most studies have shown that people are more attracted to a path that curves to one that is straight (Kaplan & Kaplan, 1998).

Aesthetic Design Principles

The principles of aesthetic design should culminate in creating attractive spaces for humans. Creating spaces spans various scales from distant views to secluded meditation areas. Elements that apply are vertical structures, transitional boundaries, enclosures, nodes, and entrances.

Implementing aesthetic design principles within treatment wetlands presents manageable challenges. Designers may be forced to work with cultural anxieties related to sewage, bleak open views with little vertical structure, and few opportunities for motion. However, since treatment wetlands provide a setting unique to most ecological landscapes, common aesthetic issues are tempered and design opportunities abound. Alteration of already modified landscapes is usually more accepted. The open views and vistas allow more opportunities through design to control visual access.

Coherence, Legibility, Complexity, and Mystery

How can we define the aesthetic principles and themes applicable for a constructed treatment wetland? Although individual responses may differ, a general understanding of how people react to different environmental settings and features is known. Principles or themes that affect the human aesthetic experience are well documented. These principles are established in the literature and supported by visual preference surveys.

Rachel and Stephen Kaplan have defined much of the early framework for understanding aesthetics within the environment. One of the most well known conceptual models of how people understand the landscape is portrayed in Table 5.1.

Table 5.1 - Kaplan's Matrix (Kaplan & Kaplan, 1998)

	UNDERSTANDING	EXPLORATION
2-D	Coherence	Complexity
3-D	Legibility	Mystery

The matrix focuses on human perceptions of natural landscapes. The two-dimensional plane "involves the direct perception of the elements in the scene in terms of their number, grouping, and placement." The three-dimensional plane "requires the inference of the third dimension. When viewing scenes, people not only infer a third dimension, but imagine themselves in the scene" (Kaplan & Kaplan, 1998:13).

Coherence infers order and organization within a setting through uniform textures, repeating themes, clear regions or divisions, and results in producing distinct places. Having a clear and readable view is often not what natural wetland landscapes entail. Natural wetland landscapes often have very little conformity. However, constructed treatment wetlands often include large bodies of open water, homogenous emergent plantings, and berms which act to unify the landscape. Picturesque landscape characteristics are often associated with this principle, particularly clear regions of open water, uniformly grazed rolling hills, etc.

Distinctive, memorable components within the landscape create legibility. Within a wetland landscape, legible elements are often composed of internal tree groves and islands, built structures, or distinctive planting. Unique or memorable elements within an extremely large wetland provide an important means for way finding and orienting oneself. Also, a legible entrance can provide ease of access and more community awareness.

Complexity implies richness, contrast, and distinct different visual components within the landscape. A large field with little or no vertical diversity lacks complexity and probably gives very little reason to explore the area. Within treatment wetlands, berms help break the monotony of the smooth water surface. Emergent vegetation along the edge of wetland cells also adds richness. A wetland cell planted with tall vegetation such as bulrushes can act as a dull visual wall.

Mystery provides the promise of more information. Most treatment wetlands have something to explore but no interest because visually all of the scenery is completely available. Besides waterfowl, there usually isn't anything compelling visitors to come closer or expend the energy to travel throughout the site. Foliage is the most available component to add interest and intrigue.

The two-dimensional plane is where understanding of the landscape takes place. If the second dimension is understandable, humans are more likely to feel safe, at ease and welcomed to the space. Within the third dimension, humans mentally explore spaces. Humans make decisions whether to physically investigate the spaces largely based on their evaluation of three dimensional explorations. If an evaluation of the third dimensional landscape of a treatment wetland is low, there will probably be fewer visitors that explore the site. Overall, the conceptual aesthetic model could be summarized by the following. "A place needs to be rich enough to invite exploration, but coherent enough that one can understand it" (Kaplan & Kaplan, 1998:50).

Safety and Restorative Environments

The Kaplans also emphasize the perception of safety. "Feeling safe is a prerequisite to the use of urban open spaces" (Kaplan & Kaplan, 1998:32). An Australian survey suggested that the strongest predictor of community visitation was possibly due to safety concerns (Syme, Fenton, & Coakes, 2001). Common fears around wetlands include fear of snakes, alligators or getting lost. The Kaplans suggest that the best way to overcome fear is through understanding the landscape through the application of the earlier principles discussed.

The Kaplans also focus on restorative environments and the benefits associated with them. Restorative environments are those that provide areas of separation from distraction or relief from the mundane. Elements of such environments include activities that allow meaningful thought or quiet fascination such as fishing, bird-watching, people watching, walking, or just sitting on a bench listening to the birds or watching the water. Multiple benefits include a clearer head, less irritability, and better concentration (Kaplan & Kaplan, 1998).

Views

Landscape visibility describes the accessibility of the landscape to viewers, referring to one's ability to see and perceive the landscape. Landscape visibility can be a function of several interconnected considerations, including proximity to viewing point, degree of discernible detail, seasonal variations (fog and haze can obscure landscapes), time of day, and presence or absence of screening features such as landforms, vegetation, and/or built structures (Visual Resources/Aesthetics, 2004).

Views need to have coherence and focus. This helps capture attention and also provides structure. Viewing stands, human nodes that include trees, and large habitat islands with vertical vegetation all help create focus points. These can help direct one's attention and help anchor one's navigation through the site. Viewing platforms can create a sense of control by permitting the viewer to see more, encourage mental exploration, and reveal areas previously hidden. Platforms are not as helpful for areas without islands or nodes, or for flat, unvegetated areas. Blinds can also help create focused views. If a nature center or interpretive building is incorporated within the site, control view from the building should be a design objective.

A problem results from the lack of variation arising from utilizing the same plant species for most treatment wetlands. Instead of planting in patches, tall plants such as bulrush and cattails are often planted in a uniform manner throughout cells and quickly reproduce to cover the entire cell. These types of planting can restrict or overwhelm the view. This phenomenon can be overcome by siting plants to create an intentional visual obstruction or built view. Plant control methods can be employed to allow intentional views into an environment from favorable points (France, 2003:56).

Large ranges of flat cells with layers of vegetation, depth, and detail offer attractive views and vistas. However unrelated or scattered vegetation or vertical structure can become a distraction. Distinct regions or groupings help organize the view and make it coherent. The typical open water cell with berms and little vegetation do little to create these distinct areas or regions.

Exposure, instead of a sense of discovery, is often the feeling that treatment wetlands portray. Trees function as the main design feature to build aesthetic spaces. In an urban setting, trees have been proven to add significant values. A number of studies have show that real estate agents and home buyers assign between 10 and 23 percent of the value of a residence to the trees on the property (Values of Urban Trees). Trees are difficult, however, to integrate into a treatment wetland. Existing trees struggle to adapt to any major changes made in the hydrologic regime. Except for the rare circumstance of isolated elevated areas, use of existing trees is usually not practical.

Since bird watching provides part of the environment necessary for humans to experience a restorative experience, designers need to focus on the settings from which birds can been viewed. For wetlands, bird-watching, a passive recreational activity, may be the largest draw for the public. Serious bird watchers often keep track of migratory bird patterns and compete to sight rare species for that region. Sign-in areas with bird citing logs add to the experience and opportunities offered by the park.

Vertical Structures

Addition of vertical structures is another way to increase complexity, mystery, visual interest and reiterated forms. Vertical structures also allow for enclosed spaces, which help create readable and interesting spaces and increases the setting's sense of discovery. Maintaining a sense of enclosure allows for comfort, more scale appropriateness, and reduces feelings of exposure, such as one would feel in a large open field.

Elements that create vertical structure include trees, shrubs, earthen berms (linear or raised islands), and built structures such as viewing decks, pavilions, blinds, and even boardwalks. Vertical structures can add significant preference to wetland landscapes by creating distinct regions and providing shade. Treatment wetlands that open fields with no respite from the sun for visitors can be less inviting. Designed structures that provide shade should be overhead and preferably provide shade where visitors can rest. Double story viewing decks, viewing gazeboes, and benches underneath trees all provide highly desired shade from the heat of the sun.

Nodes

Nodes can act as landmarks or as organizational connections within a cognitive map. Since berms are linear in nature, paths along berms are very likely to have multiple intersections with one another depending on the size and cell design. These intersections or nodes can act as key points for the integration of additional vertical structure such and signage. These points also work as points to include amenities such as benches, garbage receptacles, etc. If possible to aid in way-finding, distinctive articles, space arrangements, or notable signage should be added. These intersections constitute areas where humans are likely to congregate while resting, people watching, or waiting for others. Other areas that act as nodes include entrance areas, any service buildings (restrooms, centers, etc.), areas that tie to different internal or external regions, or other built structures on site.

The tree arrangement at nodes is also important. Most areas within treatment wetlands are planted specifically for habitat and treatment qualities. In nodes, the opportunities to design placement and select types of trees that appeal to humans open itself up. Tree arrangement can create regions (linearly planted), spaces, sense of enclosure, and can influence direction. The arrangement can also be integrated into the vertical visual landscape by planting shorter tree and shrubs on the edges.

Although wetlands vary in structure, size, and form, the main focal point of wetlands often includes water. Within a natural wetland much of the landscape can seem disorderly, incoherent and perplexing. Clear, delineated, and visible areas of open water create coherence, legibility, and focus to the landscape. Treatment wetlands often display either open water areas or a cacophony of plant stems, leaves and twigs. (Marble, Aquatic Diversity/Abundance, 1992).

Large created wetlands can impose a repetitive landscape with few or no distinguishable elements. However, depending on the view, berms can act to divide the landscape into distinct regions which contributes to a preferred view. Berms are important in understanding depth in wetland landscapes because berms usually constitute key reference sources. Berms create definable bands; property boundaries can create an end.

Regions

Different zones of patterns or use create discernable areas. Well designed treatment wetlands can integrate the surrounding landscape regions into the core of the constructed area. Outlying forest areas, nearby streams, nearby natural wetlands or meadows on or off-site help to create those regions within the landscape. Large treatment wetlands usually have different zones of treatment, one with less depth and higher vegetation, and the other with deeper and more open water. An important differentiating cue between these zones can be created with tall vegetation and trees, flat use areas, amenities, lookout platforms, blinds, or wider berms. Individual wetland cells can function as regions, although, too many regions can tax ability to mentally organize the place.

Since humans usually prefer edges, focus on transitional zones can play an important part in inviting human interaction with the landscape. Principles of transitional zones overlap with those of cultural cues and safety. Because open spaces can be daunting, careful design of these zones of transition can decrease apprehension and increase the appreciation for the spaces. Divided spaces or regions can make the place more manageable and safe for the human aesthetic experience.

Pathways

Winding paths help create bends and interest (mystery) and need to be made of distinctive material. Surface colors, textures, path widths, and adjacent plantings can all emphasize or de-emphasize the path. Loop paths should enter on the right (Hultsman et al. 1998). Established flow direction is also important for loop paths so visitors are not required to pass each other as much and thus perceive the area to be more inviting and less crowded. However, if possible, interconnected path systems are better than loop trails. Curvilinear paths in perceived natural areas are more attractive than straight paths(Kaplan & Kaplan, 1998:91). For frequent users, linear paths offer less long-term interest due to predictable, exposed views and experiences.

The width of the trail affects the intimacy of the experience. Humans feel more distanced from their surroundings with wide paths(Kaplan & Kaplan, 1998:91) such as twenty-foot wide berms. Boardwalks give a sense of distance from the surroundings as well. This may be advantageous when considering most people's fear of wetlands, especially ones with alligators. More intimate trails could be used in "protected" areas that have some perceived distance from the wetlands. Some enclosure and shade increase the intimacy of space but continue to allow trails to seem open and deter fear. Use of wider trails within natural areas (outside of already altered areas) can significantly impact fragile habitat.

Edges

Open water bodies play a prolific part in treatment wetlands. Thus, a central transitional zone becomes the water's edge. Humans find natural interest in water and are often attracted to its edge. However, the color and smell of water affects the attractiveness of it. Foreign objects such as styrofoam or an abundance of debris can be unattractive as well. Odor plays a large role in the particular design of treatment wetlands and should be remotely located from areas of human interaction through careful design.

Treatment wetlands afford the opportunity to enjoy the edge with carefully controlled design. However, the water's edge in wetlands is different in people's minds than a clean edge of a lake. Treatment wetlands often have emergent vegetation on the edge and steep berms do not provide safe interaction areas. Some fears concerning wetland water edges can be real. Alligators and snakes can be real safety concerns. Boardwalks, blinds, and specific viewing stations can offer safety, ecological safety, and satisfy humans desire to be close to the water.

The walking edge is another transitional zone that can be overlooked. As visitors become interested on a distant view or animal, their eyes may be diverted and they may often stray off the path. Dirt paths with no boundary with a steep slope into the water can be hazardous. Vegetation, low fences, or grade change can aid in creating edges.

Wood fencing can also stop desire lines, reduce erosion and increase sense of place. Use of soft materials such as wood can be helpful in containing path erosion. Boardwalks are highly preferred walking structures and can permit access to fragile areas and provide views that people normally can't experience. They can also provide opportunities to walk through dense vegetation without feeling uncomfortable. Benches offer people to take in the background. When walking, most of the surrounding world is background.

<u>Gateways and Signage</u>

Although there is usually only one site entrance, there may be multiple gateways within a treatment wetland. Gateways are where visitors can make informed decisions as to whether to enter. It should facilitate finding one's way. Gateways can include information, site maps, restrooms, interpretive facilities, and picnicking areas. Often large signs are tempting design elements, but if designed correctly, signage often isn't needed. The design should intrinsically tell people that they have arrived. This can include actual gates, pavements, or built structures such as central meeting areas. The view into the site from the gateway can be enhanced by affording partial views that show enough to be interesting but still beckons to explore the space.

Parking areas play an important role in inviting and preparing people for the general environment for which they are entering. Parking can be detached from the wetland or integrated into the site. Since wetlands act as natural educational facilities, progressively environmentally sound practices such as permeable pavement ought to be considered. If possible, one major path from the parking lot to the gateway should be used. No other alternate pathways should be offered, thus reducing the confusion and focusing attention on the controlled entrance.

Often problems arise when the treatment wetland is situated near the wastewater treatment plant. If the wastewater treatment plant is located near the wetland, this transitional zone can be one of the most important design elements that effect visitor frequency. The relationship with the treatment wetland and wastewater treatment plant should be acknowledged, but a strong visual association does not usually prove tasteful or attractive. Treatment wetlands that heavily buffer the view from the wastewater treatment plant effectively reduce this association.

Also associated with the transitional zone between the wastewater treatment plant is the site boundary. Heavy screening with vegetation can help avoid distractions and buffer views from any busy areas near the site. Also important are the views into the site from possible neighboring subdivisions. Berms and vegetation can be effective for both parties.

Simpler is often better for trail signage. Symbols can, at times, be more effective than words. Un-shaded signage can severely deteriorate over time without the proper materials for signage. When visitors visit the wetland, they experience a snapshot of the processes at work, which can be quite boring. Effective signage includes those that introduce multiple frames of time such as geologic, seasonal, and diurnal to be expressed. Essentially, signage allows the dynamic ecological processes of the wetlands to be highlighted (Kaplan & Kaplan, 1998).

Maps

Unclear maps can confuse people rather than inform and entice them into the space. With multiple berms and possible paths, clear maps and outlined paths are crucial in treatment wetlands. Maps with clear circulation can help avoid confusion. Since all treatment wetland berms should be maintained but may not act as useful recreational paths, clear signage at these entrance points can be helpful. Indications of previous human use such as well worn paths, benches, signage, or delineated vegetation can be comforting and highly preferred.

Paths on maps should be bold. If multiple paths are designed, then a tiered label system should be applied with primary path routes being thicker and secondary or tertiary paths showing as thinner and/or hidden lines. Legends can be used but features occurring only once on the map, such as a blind, should be written to decrease the viewers confusion of going back and forth from the legend to the map. Maps with too many symbols are difficult to read and understand. Fixed maps should be oriented in correlation with the background view. In most cases this will require the north arrow to be pointed somewhere besides directly up on the map (Kaplan & Kaplan, 1998).

Maps in popular treatment wetlands are often used by joggers, hikers, and bikers marking distances with posts or signs throughout the wetland can encourage daily recreational users. Maps should identify wetland cells, facilities, significant built structures, nodes, landmarks, trailheads to offsite paths or areas, and outlying areas.

Since nodes also function as key decision points, they need to be clearly identified on maps, especially if several path options can be made at those points.

Maps should not include more information than needed. Outlining existing vegetation, for example, is probably too much information. Landmarks, choice points or nodes, and regions should be labeled. Shading outlying land or parcels can help focus the important parts of the map and improve visual interpretation.

Conclusion

Understanding of aesthetic principles has been revealed through study of the human thought process. Understanding of these principles is sound and designers have an obligation to apply them. Ecological landscapes have proven to be challenges with multiple issues such as visibility, temporality, reiterated forms, expression, metaphor, cultural cues, and motion. Principles and themes important to improving the aesthetic appeal of treatment wetlands include: coherence, complexity, legibility, mystery, safety, restorative environments, views, vertical structure, nodes, depth, thoughtful signage, paths, focus on transitional zones, and understandable maps. As designers take time to consider each of the mentioned principles and themes, treatment wetlands will be more inviting places for human interaction.

CHAPTER 6

AUTHENTICITY, ETHICS, AND SUSTAINABILITY

Introduction

Wastewater treatment wetlands are, by their definition, wetlands that treat human byproducts. Through utilizing the benefits of natural wetland processes, we have harnessed a natural phenomenon as technology. Authenticity, ethics, and sustainability all provide different views about the challenges involved when creating and designing treatment wetlands. What makes an altered wetland authentic? When does human control over a system make it into just a fake ecosystem? Where is the line between authenticity and accommodating human desires? Questions such as these are integral to understanding the limits to which aesthetics can be advocated.

Authenticity

Authenticity and ethics of manipulated wetland systems have emerged while discussing mitigation techniques (Batzer & Sharitz, 2006) and validity of cultural history and artifacts (Howard, 2003:61). Others have emphasized tourism, growth, exploitation, and the environment (Physical Alterations and Destruction of Habitats (PADH), 2008) as it relates to the authenticity of created wetlands. The specific addition of aesthetics and treatment wetlands possibly generates a unique yet, valid discussion.

Due to anthropogenic forces, there are arguably no perfectly natural wetlands on earth. Whether indirectly or directly, all wetlands have been altered in some way by humans. A range of human alteration has been imposed upon different wetlands. Created wetlands probably rank quite low on a scale of naturalness, yet there has been little discussion about human perception of altered or created wetlands. As natural processes take over from the time of disruption, a created wetland also becomes more natural or authentic. Admittedly, years after a wetland is created, natural vegetative growth misleads most observers to overlook artificial creation of the wetland. Most practitioners have adopted the attitude that when one creates wetlands, they only set in motion the processes that allow a wetland to naturally form. The only major disruption after initial wetland creation is management of unwanted invasive species, removing dead plant material, or removing excess sediment within selected cells.

So the question must be asked, "Can the creation or management of wetlands become innately unnatural?" Some Japanese gardens provide examples of highly controlled wetlands. These types of landscapes are renowned for their spiritual and culminating qualities, yet they can lack healthy ecological dimensions with manicured lawns, excessive pruning and loss of natural seed rejuvenation. Other landscapes that strive for aesthetic over ecological benefits include classic pastoral landscapes.

History shows that we can transform landscapes into a very unnatural yet aesthetic environment. Examples of transforming landscapes to create a 'super aesthetic' include creating condensed micro wetlands, building synthetic props , overpopulating the landscape with built structures, or cluttering the view by concentrating too many visually interesting things in one place. Aesthetically most of these strategies fundamentally elicit the opposite of the desired effect when viewed from a holistic perspective.

Since designers are often under pressure to provide high accessibility and accommodate multiple preferences, there is a tendency to attempt to create extremely diverse and therefore overloaded landscapes near interpretation areas, nature centers, or entrances. This allows observers get a condensed and convenient short tour of the wetland without really experiencing the wetland itself. This type of condensing may be appropriate to some extent for indoor exhibits, but completely out of context and unauthentic to a properly functioning wetland.

If creators attempt an authentic ecological and aesthetic environment, then they must design with that attitude. Mozingo states, "…if our underlying attitude in ecological design is in compensatory reaction to human existence, *it will show*—it will have an attitude of apology, if you will, that will ultimately lack power" (1997:57). Because wastewater treatment is actually a response to what could be considered as human overabundance, a pitfall may be to over screen or over adorn wastewater treatment buildings or facilities. For example, a small flower bed in a left over space by a wastewater treatment plant may seem to be the epitome of an apologetic, compensatory reaction to the bareness of the concrete and steel structures behind it. Designing a semi-natural treatment wetland that allows nature to flourish after human input, however, seems quite opposite. Other negative elements commonly found in treatment wetlands are chain link fences. They often suggest unsafe or uncomely views. However, standard design requires that wastewater treatment plants be fenced in.

Although this could be seen as a huge design issue, berms and vegetation can slightly ameliorate this problem. Also, instead of completely screening views from the wetland to the wastewater plant, preferable and carefully chosen views may be most appropriate.

Both Thayer and Thompson-Sorvig mention that true aesthetics don't include deception of function or of alteration of natural forms (Thayer, 1994:310; Thompson & Sorvig, 2000:16). Hough also stated, "…the conventions and rules of aesthetics have validity only when placed in context with underlying biophysical determinants" (1984:25). Under this definition, many created wetlands for wastewater treatment scream out counterfeit beauty because the underlying hydrology is artificially sustained. However, working with the given landscape requires less earth moving, reduces costs, maintains some character of the land, and often forces designers to be more creative. Also, accentuating natural land forms may be appropriate and within the context of utilizing original resources.

"Today we find ourselves in a deeply fragmented situation where we love nature, but depend on technology" (Thayer, 1994:94). Treatment wetlands provide a solution that works at ameliorating our internal dissonance between the negative wetland and technology syndrome. Thayer presents the term 'landscape guilt', asserting that "Americans . . . feel guilty about what technological development has done to the landscape, to 'nature', and to the earth" (Thayer, 1994:94). Treatment wetlands designed with authenticity in mind present a technology that is relatively guilt free.

Ethics

Beyond authenticity comes the responsibility to nature, especially after we toy around with it. Ethical issues with treatment wetlands include initial and continuing alterations of the natural environment, human disruption of wildlife, deceptive portrayal of the landscape, and commodifying wetlands. Designers need to be aware of the changes occurring within the system when a treatment wetland is being created and the design strategies that can avoid ethical issues.

When secondary waste is added to a natural wetland, the hydrologic cycle is changed. Natural wetlands may only be inundated with high water tables certain parts of the year. When a constant flow of partially treated wastewater is added throughout the year, the hydroperiod, or times that the wetland is inundated with water is drastically changed. The amount of water is also very significant to the existing vegetation. Natural wetlands are more sensitive to hydrological changes than created wetlands due to older and more established woody growth. The amount of nutrients within the water source also creates challenges for vegetation and can begin to change the vegetation make up by benefiting different plants that absorb higher nutrient loads.

Since treatment wetlands are predicted to only last about 30 years, questions remain as to how to handle abandoned wetlands. Having introduced new hydrology, flora and fauna, and then drastically altering the water supply, drying up the wetland, and changing the ecosystem again begs to question our ethics. If we intentionally cause a wetland to dry up, we essentially destroy it. In normal wetlands, this would require mitigation. Therefore regulatory mitigation requirements for future abandonment of a project may be in order.

Since wetland systems create habitat for many large range animals, the human disturbance factor becomes even more significant. Fishing and nonconsumptive recreation are projected to increase 63% to 142% over the next 50 years (Knight & Gutzwiller, 1995) With this expanded desire to view and recreate in nature areas, moderating human influence on animal populations within treatment wetlands can become a sensitive design issue since nature viewing can have a direct negative effect on wildlife. Primary impacts of animals through nature viewing are disturbance, habitat modification, and pollution (Knight & Gutzwiller, 1995). Some of the most detrimental disturbances occur at breeding season due to the effect on the animal's productivity or attention to their young. Predators may also learn to follow human scent trails to nest sites and avian predators learn to forage in the vicinity of people who

are visiting bird nests (Knight & Gutzwiller, 1995). Waterfowl is usually the primary human interest for visiting wetlands.

Whether natural or created, wildlife eventually populates wetlands, especially large wetlands. Research has shown that amphibian mutation rates have been unusually high in treatment wetlands (Ruiz, Davis, Fish, & Maerz, 2007). With a wide range of factors in play, careful planning and research need to be done for each particular case. Ethical challenges apparently exist when placing a constructed wetland.

The placement of treatment wetlands poses another important issue. There is an ethical conflict in creating a superficial ecosystem outside of the natural setting of a normal healthy functioning wetland. Humans often innately detect contradiction within the landscape. Unless purposely done as an artistic statement, this type of ironic scenery breaks down the authenticity of place.

As our society slowly continues to realize the value in wetland creation, wetlands are beginning to be treated more as commodities. As, France put it, “the recognition of a wetland premium” (France, 2002:357) has begun. Some estimates of real estate values for properties adjacent to natural wetlands decreased (Kiel 2007), while others have estimated increases in real estate value (Schuyt & Brander, January 2004). Ghermandi estimates that economic value for constructed wetlands increase (2005). Clear land value increases can be seen with mitigation efforts. Wetlands that have been drained, dredged, and filled, or altered in the past are beginning to have significant marketability as mitigation sites. Agricultural wetlands that were legally drained many years ago create opportunities for existing property owners to cash in on favorable wetland mitigation sites. This poses an important ethical question, “As a society, should we pay people that contributed to the existing harm of our watersheds to repair what they were paid to originally damage?”

Compensatory mitigation is problematic because most mitigations sites are chosen for their location and not the wetland function that they are replacing. A common scenario replaces a healthy, diverse and complex wetland system with a hole in the ground with water at the bottom. When significant differences exist such as hydrology, soil type, planting, extent of water edge, micro invertebrates, and depth of water column, then the functions are significantly changed.

The opportunity to count treatment wetlands as mitigation sites has the potential to create healthier, more dynamic wetland systems than the alternative that is offered through compensatory mitigation. If treatment wetlands are used, careful consideration and design must still be given to the original functions of the wetlands being replaced.

Sustainability

In defining sustainability, the National Park Service states:

> . . . Sustainability as related to park planning design, and development means meeting present needs without compromising the ability of future generations to meet their own needs. Sustainability minimizes the short and long term environmental impacts of development activity through resource conservation, recycling, waste minimization, and the utilization of energy efficient and ecologically responsible materials and procedures for construction (Campbell & Ogden, 1999).

In 1993, the American Society of Landscape Architects defined sustainable development as “development that meets the needs of the present without compromising the future” (Campbell & Ogden, 1999). Thayer further defined the requirements of sustainability to be transparent, congruent, and use only moderate energy. Sustainable landscapes will:

1. Use primarily renewable, horizontal energy at rates which can be regenerated without ecological destabilization.
2. Maximize the recycling of resources, nutrients, and byproducts and produce minimum ‘waste,’ or conversion of materials to usable locations or forms.
3. Maintain local structure and function, and not reduce the diversity or stability of the surrounding ecosystems.
4. Preserve and serve local human communities rather than change or destroy them.
5. Incorporate technologies these goals. In the sustainable landscape, technology is secondary and subservient, not primary and dominating (Thayer, 1994:243).

Multiple texts include treatment wetlands as a model for sustainability (Lyle, 1996) (Spirn, 1984) (Mozingo, 1997) (Campbell & Ogden, 1999). Treatment wetlands are appealing examples for sustainability because they can rely almost solely on natural energy in place of mechanical means such as pumps, concrete structures, and addition of chemicals. Another desirable feature is the low maintenance required. The complete system can be operated for days without any human intervention. Overall, treatment wetlands have the "ability to provide multiple functions and benefits at low cost and with low environmental impact" (Campbell & Ogden, 1999:3). Beyond the treatment functions of a treatment wetland, the capacity to reutilizing these landscapes for human recreation and enjoyment is yet another sustainable characteristic.

Eco-revelatory design, or making visible the ecological processes that make up or surround designs, is a direct application of sustainable design and happens to be extremely relevant to treatment wetlands as well. Although coined just in the last 20 years, the principles of eco-revelatory design can be linked back to Frederick Law Olmstead. The Emerald Necklace has been heralded as one of the best and earliest examples implementing multiple goals beyond human recreation by highlighting the ecology of the back-bay fens as stormwater management, sewage treatment and as an aesthetic attraction (Zaitzevsky, 1982).

Elissa Rosenberg discusses that the word "infrastructure" has recently been changed to "public works", and for good reason. "Infra" means "down, below or under" suggesting that infrastructure is unseen, unwanted or possibly even discarded pieces of our culture. Rosenburg suggests that uncovering and rediscovering these pieces of our culture can be extremely valuable in our landscapes. Examples include, stream day lighting projects, restoring old waterworks projects, or unearthing and highlighting any forgotten piece of culture such as swimming pools, water quality filter beds, or any pipe collection system. Treatment wetlands essentially highlight and naturalize the processes that have traditionally been hidden behind pipes, concrete and steel.

Nassauer has said, “neither protection nor revelation necessarily involves people in maintaining ecological quality in the landscapes that are part of their everyday experience” (Nassauer 1997:78). In other words, eco-revelatory design or preservation of landscapes itself does not engage community or bring about invested caring opportunities. Eco-revelatory design should function as a tool to initiate public connection with the wetland ecosystem with supplemental community integrative encouragement.

Conclusion

A suitable analogy for the relationship between authenticity and aesthetics may be the difference between designing a miniature golf course and a golf course. A miniature golf course can be phony, super-exaggerated, unnatural and deceiving, while traditional golf courses try to maintain an amount of naturalness that most people find legitimate and acceptable. Treatment wetlands, like golf courses, are highly manipulated sites. Designers have a major role in applying ecologically sound and aesthetic principles.

CHAPTER 7

SEPARATE DISCIPLINES, ONE SOLUTION

Introduction

Although many professionals have a broad range of skills, the subjects of functionality, ecology, and aesthetics correlate directly with the professions of engineering, environmental science or ecology, and landscape architecture respectively. Due to the fact that few environmentally favorable human endeavors have the capacity to reduce waste while creating new ecosystems, treatment wetlands provide a unique environment for integrating disciplines. When the depth, understanding, and competency of all three disciplines are explored and expressed, the design choices for any treatment wetland will display greater coherence, creativity, and collaboration.

Functionality

Most research on treatment wetlands has focused on maximizing nutrient removal through managing the water distribution and establishing robust plant communities that efficiently remove constituents from the water. Due to the technical nature of regulating wastewater, treatment wetlands have traditionally been designed solely by engineers. Engineering, by nature, is based on functionality. The form of the wetland has almost always been dictated by the function of the wetland cell to maximize the treatment of the wastewater.

To create economically feasible treatment wetlands, maximizing land usage has always been of the utmost importance. This usually means designing as much wetland and as little “wasted” upland as possible. In this regard, both ecology and aesthetics seem to be at odds with engineering. Less upland usually equates to fewer trees, less wildlife habitat, and less human interest or uses. However, this issue may not be as unresolvable as the opposing disciplines make it seem. With proper planning, purchased or existing land tracts often have excess land. For example, the Indian River wetlands has an estimated 15 acres of unused grassed lawn at the entrance that requires consistent maintenance. Often the challenge is only integrating uses.

Also, to keep calculations relatively uncomplicated and to maximize hydraulic efficiency, wetland cells have traditionally been given a rectilinear form. The ease of hydraulic calculations has limited experimentation with other form vocabularies and thus the rectilinear has become the main form of choice. This approach can limit design options for human uses. Alternatives such as symmetrically rectangular wavy berms have reduced the stiffness of the form. Another alternative includes designing curvilinear berm forms in deep water cells where there is more emphasis on nutrient transformation instead of nutrient removal.

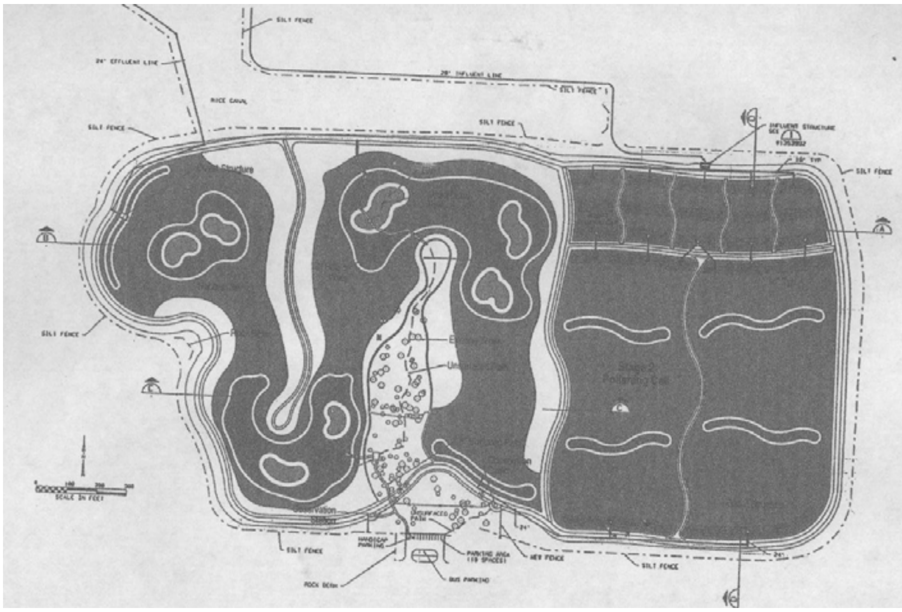

Figure 7.1 – Plan View of Victoria Wetlands.

(France 2002).

With limited budgets, engineers have been successful in creating bare boned wastewater facilities that perform the functions with little attention to outward appearance of the landscape. When treatment wetlands have begin to interest the public, and then invite visitors, the conventional design mode of concealing wastewater treatment and its appendages is turned upside down. This new paradigm changes the traditional community waste problem into an open community landscape. Although changing a problem into an asset is a great idea, there are multiple design and budgetary challenges that surface. The design process becomes larger than one discipline has capacity to handle. An increased budget for the appeal of the wetland and surrounding landscapes may also be required.

Ecology/Wildlife

Ecology has always naturally been a part of wetland creation, whether we have acknowledged it or not. A basic ecological principle states that the more complex the community structure, the more niches and the more species there will be (Colinvaux, 1973: 621). Benefits from rich ecological structure can add wider contaminant removal capacity, support more wildlife, and can create more interest for human enjoyment. However, the addition of design criteria to enhance ecological diversity or increase habitat often conflicts with other objectives.

For instance, Marble (Wetland Dependent Bird Habitat Diversity, 1992) outlined design aspects that are important to bird habitat within created wetlands:

1. The proportion of water to vegetation should be roughly even.
2. Create several small areas of different vegetation classes.
3. Provide a predominantly forested or scrub/shrub vegetation cover.
4. Include strands of woody or emergent vegetation within the wetland.
5. Include one or more islands.
6. Provide an organic substrate.
7. Create an irregular edge between the wetland and the upland.
8. Minimize human disturbance in or near the wetland.
9. Avoid urban watersheds.

These recommendations should be supplement to engineering and aesthetic principles. Although most recommendations may be partially accommodated, they embody major challenges. For example, organic substrate, irregular edges and forested vegetation cover may all be impractical to implement. Even among ecologically sound principles, different objectives can cause principles to contradict one another. For example, to attract the most ducks to wetlands, management strategies suggest drying out the wetland every five years to keep emergent vegetation low and submergent vegetation high. However, normal ecological principles would suggest allowing natural diversity of plant communities to develop.

Ecology also struggles to find compromise between a desired pristine environment and the reality of a highly altered one. Research may show how it should work as a natural system, but limited understanding exists to find ways to maximize processes and connections within a manipulated system.

Although there seem to be major conflicts, overlap and agreement with some principles do exist. For instance, healthy ecosystems often attract humans. Also, addition of multiple vegetation types for habitat complexity also serves as an efficient nutrient removal strategy due to various plants preferring different nutrients and having different uptake rates. Creative solutions such as sections of created wetland dedicated to different objectives can overcome perceived impasses.

Aesthetics

The ideas of integrating aesthetics into treatment wetlands has been the last and least expressed in research literature. Aesthetic considerations are important not only to attract and retain visitors, but also to increase community support and eventually project funding. Although aesthetics may often have been overlooked, any aesthetic consideration must be made within the parameters of the ecological and engineering constraints. It does no good to design a dysfunctional wetland that seems to be completely aesthetically pleasing.

Although aesthetics and ecology may prescribe similar or overlapping recommendations, the human perspective is not as definitive. Gobster et al. said it this way, "Humans cannot directly sense ecological quality, though there may be a tendency, based on evolutionary processes and cultural expectations, to assume that good ecological quality is associated with good aesthetic quality" (Gobster, Nassauer, Daniel, & Fry, 2007:962). Principles of aesthetics cannot be used as a substitute for ecologic quality. Aesthetics can, however, promote human appreciation for ecological principles. Creating human connection with spaces that portray ecological properties indirectly promotes ecological objectives.

Wetlands are ecotones; the edge between water and land. They are constantly changing and very sensitive environments. Creating human interactive sites within a wetland can interfere with some large wetland animal species such as blue herons. This interaction needs to be balanced to offer the best human experience but not be overbearing on wildlife or the emerging ecology of the wetlands.

Within the three relationships, aesthetics and functionally may seem to conflict the most. However, because functionality can add structure and organization to a landscape, functionally aesthetic landscapes may be most appealing within treatment wetlands. The relationship between ecology and aesthetics can work synergistically or at odds with one another. Because "…ecological design changes the very currency of landscape architecture from aesthetics to science" (Mozingo, 1997:49), ecological recommendations can often be made without any consideration of humans. Common aesthetic challenges include communicating desired elements and difficulty in the level of quantifying aesthetics as a means to create designed spaces and environments. Other challenges include understanding of the role of aesthetic concerns compared to functional concerns and defining relationships with real budgetary and the level of aesthetic detail.

Creating a Holistic Solution

Due to the reality of budgetary constraints, capable professionals have often been expected to make difficult decisions outside their primary area of expertise concerning treatment wetlands. This type of "profession hopping" can result in skewed decisions and unfulfilled objectives. Designers of hydrologically based systems must consider landscapes for their multiple functions, services, and users. Collaborative design approaches can eliminate such weaknesses, help keep objectives clear, and be a catalyst for creative ideas. The challenge is to work together to implement them all.

The following table shows some of the fundamental recommendations from different design subjects. Each recommendation is compared with the other disciplines. The chart shows that relatively no recommendation will benefit all design characteristics. However, with constructive ideas, many recommendations can be implemented to benefit most design objectives.

Table 7.1 – Table of Fundamental Recommendation and Their Relationship

DESIRED QUALITY OR FEATURE		TREATMENT FUNCTION	ECOLOGIC FUNCTION	AESTHETIC FUNCTION
Ecological Quality	Wide greenways.	- Competes for land areas with wetland.	+ Creates multiple species with travel connector.	+ Increase depth of landscape, exploration, scenic diversity.
	Diverse water depths, low sloping edges.	- Possibly creates multiple short-circuits. Slight land increase requirement as berms must be wider.	+ More habitat diversity.	+ Visual diversity, less separation with water body. - More careful design and signage required to keep people away from water
	Dispersed structure	- Can create uneven flow path, short-circuits, and uneven friction.	+ More habitat diversity.	- Lack of visual organization.
Efficiency	Hydraulic Efficiency	+ Even depth, velocity, and shape create a more efficient climate and is easier to construct.	- Low plant diversity, scale of anaerobic and aerobic activity is regionalized. Sediment loads are undynamic.	+ Provides separation; berms provide visual banding and a visual patchwork. Plant monoculture can provide organization. - Lacks variety, variation, interest, and vertical structure.
	Maximize land use for wetland creation	+ Better use of land for funded purpose (nutrient removal), lowers overall cost	- Lower habitat diversity.	- Less variation of land forms, less land for human amenities.

Table 7.1 Continued – Table of Fundamental Recommendation and Their Relationship

DESIRED QUALITY OR FEATURE		TREATMENT FUNCTION	ECOLOGIC FUNCTION	AESTHETIC FUNCTION
Spatial Definition	Vertical Structure	- Less efficient land use. Tree uptake has lower uptake as compared with shrubs, emergents, etc.	+ Provides habitat for nesting birds, habitat variety for users of both water and land, and possibly creates land greenways for species dispersal.	+ Addition of trees or conversion of existing overhead vegetation provides visual frame, variety, and buffers.
	Boardwalk	- Upfront cost usually outweighs overall usage.	- Loss of area for skittish birds and mammals through better human access. Can act as a habitat roadblock.	+ Increases access, interest, interaction. Leads to community approval and support.
	Curlinear	- A smaller percentage of the nutrient removal may take place. An increase of velocity.	+/- Would change the plant and animal communities from a wetland type to more of a floodplain type.	+ People appreciate stream like areas.
	Forms or Stream Flow			- Linear wetlands are less appreciated by homeowners as through hedonic pricing.

Conclusion

In advocating for the addition of aesthetic considerations within the design process of treatment wetlands, the vital importance of other qualified professionals to the design process should be validated and in no way diminished. Environmental scientists, botanists, wetland ecologist, etc. should play a strong part within the design team. Engineers obviously play a vital role and may play the most important creative role by understanding the flexibility and tolerances within the waste treatment design. Since wetland creation is an incredibly complicated, diverse and new field, many of the resources which design teams have relied on have been from their own experiences in the field. Even with disparate objectives that often seem impossible to bridge, a broad range of qualified and experienced professionals can often find creative solutions that would otherwise be overlooked.

CHAPTER 8

CONTEXT

Introduction

> *Ecological design is the careful meshing of human purposes with the larger patterns and flows of the natural world and the study of those flows and patterns to inform human purposes. . . . When human artifacts and systems are well designed, they are in harmony with the larger patterns in which they are embedded (*Orr, 1992).

The context in which we view wetlands can significantly change where and how we design them. Multiple scales of connecting elements generate a matrix of themes to consider such as ecology, hydrology, placement of wetlands within the regional and local landscape, water quality, and demographics. Sather wrote about context saying:

> Full manifestation of ancillary benefits in constructed wetlands is contingent upon several factors:
>
> 1. Species composition and degree of interspersion of plant communities (significant because of diverse habitat requirement of various animal species and because of several other types of benefits).
> 2. Location with respect to human population centers (significant because of its relation to recreational, aesthetic, education, and research benefits).
> 3. Location with respect to other wetlands (significant because some wetland species are dependent upon wetland complexes and because nearby wetlands can serve as a source of species) (1989:353-354).

Ecology

Although wetlands constitute only six percent of the earth's surface (Batzer & Sharitz, 2006), over a third of all rare and endangered species are direct residents or closely dependent on wetlands for a variety of essential purposes (France, 2003:21).

Wetlands constitute the highest productive environments in the world and also acts as highly diverse environments that support biodiversity, with larger sizes and quantities of wetlands supporting more biodiversity (Batzer & Sharitz, 2006). Dynamic shorelines of wetlands provide a multitude of habitat opportunities, while at the same time the plant and soil structure allow a multitude of plant, detritus and natural elements that provide environments for spawning, nesting, breeding, feeding, predatory refuge, and nursery rearing purposes.

Avian species associate themselves with wetlands for the abundant source of food, protection and habitat. Wetlands play an integral role in providing rejuvenating refuges for bird migration routes. Since bird watching is often the most appealing recreational activity within treatment wetlands, attracting birds becomes crucial. For maximum appeal to birds, Marble (Wetland Dependent Bird Habitat Diversity, 1992) suggests selecting a site where the wetland will be the only one within a large geographic area and a wetland type that is different than wetlands in the same region. “Oasis wetlands attract wildlife from large geographic areas, and are thus significantly greater in wildlife value than wetlands scattered evenly throughout a region” (Marble, Wetland Dependent Bird Habitat Diversity, 1992:169). Although this recommendation seems to be contrary to connecting wetlands, emphasis should be given to creating the appropriate type of wetland. Treatment wetlands naturally create appealing open water areas with multiple emergent plants that are generally attractive to birds. Also, birds are more likely to utilize the wetland if the site is next to a forested area or planted with a wide buffer around the wetland.

Hydrology and Water Quality

Wetlands occur naturally in lowlands and are delineated as depressional or nondepressional wetlands. Depressional wetlands are made up of bogs, prairie potholes, Carolina bays, cypress domes, or seasonal wetlands while nondepressional wetlands are made up of fens, swamps, marshes, pocosins, cedar swamps, estuaries, riverine or floodplain wetlands, or freshwater shoreline wetlands (Batzer & Sharitz, 2006). Many wetlands have hydrologic connections with other water bodies, whether other nearby wetlands, lakes, rivers or oceans. Because of these connections, many plant communities, mammals, invertebrates, and amphibians are able to access a wider range through the existence of wetlands. Creating a wetland that is removed physically from other wetlands may limit these connections and opportunities for ecologic complexity.

When placing a constructed wetland within the landscape, an array of important contextual questions should be considered. How will the constructed wetland fit into the landscape? Should it be placed in areas with existing high water tables? To where will any infiltrated water flow? Could any additional flow be directed to a neighboring property? What are the vegetative characteristics of the area? The answers to these questions should constitute a fairly good understanding of not only the immediate area of the wetland, but adjacent areas and their topography, hydrogeology, geology, plant communities, and human influence.

Natural wetlands are seldom used for treatment due to regulatory restraints and poor success rates. However, sites that may be always wet, or only have some seasonal water and not actually officially determined to be wetlands, have been used. If a constructed wetland is built where the natural water table is near the ground surface, some groundwater mounding or other significant changes the groundwater may occur. Areas where no surface water is present and the water table is far beneath the site have fewer risks of greatly altering the water table.

Placement of Wetlands within the Local and Regional Landscape

Steady discharge brought to any point on the landscape gives designers the full advantage of locating treatment wetlands almost wherever they choose. This creates major opportunities and responsibilities. Designers have the full ability to create wetlands as terraces on a hillside, on plateaus, on top of hills, or just about anywhere that would normally be considered an upland area. Creating wetlands in upland areas drastically changes the natural hydrology, ecology and landscape form. Natural ecological drivers would probably take millions of years to make such significant changes to an area. Also, natural land forming drivers would never create a landscape similar to a terraced wetland.

The hydrologic effect of uplands receiving wastewater include possible untreated wastewater in the water table that could divert to another property, changing downhill water table levels and sudden loss of trees and other vegetation, and creating an unstable habitat if the water source is altered or discontinued. Creating a wetland in an awkward location can also be confusing to both humans and animals. Within the context of natural processes, this type of design freedom can lead to very unnatural landscape forms.

A similar phenomenon occurred when designers first began moving and redesigning streams. After major detrimental effects were found from these activities, heavy regulation and controls were placed upon stream course modification. Similar caution should be given to significantly altering the landscape to create wetlands unnatural to the site. Although research hasn't discovered the full effects of creating these unnatural wetlands, science gives us early clues about possible problems (Riuz, Davis, Fisk, & Maerz, 2007).

Low lying land usually costs less and is more readily available due to development restraints such as flooding; however, some land for wetland creation may be acquired with significant upland areas. Higher costs usually prevent major projects with extensive terracing or extreme grading. Other beneficial uses for upland areas include recreational activities, parking, maintenance, or other utilities. Remembering the context of the site, working with the landscape, using natural low areas, and allowing the landscape to only intensify the natural ecological processes that pre-exist on the landscape is optimal.

The location of existing wastewater treatment plants is another contextual aspect to consider. Treatment plants are often purposely hidden because of the perceived negative public view. At the same time, they can often impede public access to waterways or greenways.

Although wetlands are capable of treating large amounts of nutrients, streams and large bodies of water are not as productive or resilient from higher nutrient levels. Wastewater treatment plants are often associated with low elevation points in the topography to utilize natural drainage of wastes to the plant. Poor water quality, partially attributable to wastewater treatment plants, is often associated with these streams or water bodies and thus treatment wetlands are used as a remedy. Many treatment wetlands have been built next to natural areas such as wetlands, streams, forest, marshes, and coasts. This becomes important in context to ecologic and human connections.

Sites located next to natural systems allow green space to be congruous and facilitates opportunities for meaningful trails or connections within the green network. Placing a treatment wetland near natural systems also serves to attract more people and influence a large enough visitor frequency to justify larger infrastructure such as a nature center or interpretive facility. Larger forests or natural areas add greater variety of recreational activities, create more area to be explored, and benefits from aggregation. Landscapes in which a higher number of natural elements are present are usually more preferred (Kaplan & Kaplan, 1998). Treatment wetlands can also portray an image of “cleaning up” or “filtering” original water quality problems from the area which can inspire community unity and activism.

<u>Demographics</u>

The demographics of an area greatly affect the amount of visitors a wetland can attract. Urban areas are more likely to succeed in drawing higher visitor rates at wetlands due to proximity to people. Since wastewater treatment plants are more likely to be built in more densely concentrated areas, they are less likely to be located in rural areas. They are more likely to be in urban areas with close by natural areas due to proximity to streams, water bodies or low points in the landscape. Considering the fact that many wastewater treatment plants lay in these prime areas, there is significant opportunity to incorporate treatment wetlands into an urban park system, nature conservation area, or stream trail corridor.

Conclusion

Multiple considerations must be recognized within the design and placement of a treatment wetland. The wide matrix of ecology, hydrology, placement of wetlands within the landscape, water quality, and demographics should be considered. The holistic context of a treatment wetland is best seen through the eyes of a collaborative design team with different viewpoints and knowledge.

CHAPTER 9

COMMUNITY INVOLVEMENT

Introduction

The community factor determines much of how a treatment wetland should be designed for human use. Where possible and feasible, treatment wetlands should include human use to some degree. Mozingo declared,

> Ecological spaces, especially those in close proximity to urbanized areas where most people live, should be appealing aesthetic experiences. If we expect the public to enthusiastically reorganize its environmental preferences, the ecological landscapes themselves should engage public interest and motivate support for their expansion and replication. This is central to the promotion and acceptance of ecological design (1997:48).

In order to preserve ecological landscapes, the community must support it, use it, and therefore enjoy viewing and experiencing it. Although treatment wetlands are not natural ecological landscapes, they can still be viewed in the same context.

The question remains, "Can the public value created wetlands enough to overcome the costs associated to make the space successful for human use?" If the answer is yes, then a second question remains, then "How can we soundly implement those uses?" Communities are not likely to vigorously fight for treatment wetlands to be made accessible and aesthetically pleasing. Thus most of the demand for creating treatment wetlands amenable to human use must come from the designers in the conceptual stage where objectives are being laid out. The value of the place is created after the design and implementation of the wetland. The public rarely recognizes the need for valuable accessible green space, but easily evaluates the value of a space after experiencing it once it is built.

Another reason treatment wetlands are well suited to produce places valued by the public indirectly owns them. Constructed wetlands for wastewater treatment are most often funded by the public and therefore are essentially are public domain. However, these constructed wetlands often are not accessible to local residents. Common sense would say that residents should be granted use of constructed natural areas they fund. When wastewater treatment plants contain land that can be used for multiple purposes natural cost savings are involved. Since the support of the community is tied strongly to the appeal or cultural sustainability of the site, considerable attention needs to be given to the design of constructed wetlands.

Most treatment wetlands are managed through a municipal water department, majority of whom are not trained or equipped to manage the public in a “park-like” atmosphere. Adding extra amenities and requiring personnel for safety can be costly as well. From the municipality’s point of view, the fewer visitors frequenting the treatment wetlands the better. Therefore, a strong argument for municipal water departments not to take on these responsibilities is raised. However, combining efforts between other departments, such as the parks and recreation department, can assist in ameliorating this problem and allow the municipality to be welcoming and open to the public.

The publics’ appreciation of wetlands and of parks is increasing. “Intense and diverse user demands, a well-informed and involved public, tax referendums and demands for energy conservation are but a few of the developments which have thrust the planner into an era of environment decision making" (Reed & Perdue, 1979:47). The appreciation for ecological and aesthetic standards has also been raised. Communities may not accept narrow minded landscape amenities designed to serve only single purposes. The multiple functions of these systems don't just need to be highlighted as a public service, but will be a required consideration as the citizens of community demand it. The vice president for Safety Health and the Environment at the Dupont (now Invista) wetlands said, "The community engagement that facilitated turning this wetland into an asset for habitat enjoyment and education is a model of the new kind of partnership that needs to exist at our sites worldwide" (Development, 2005:5). As the precedent is set in other areas, a higher expectation will be required in other projects and places as well.

How then can community values be incorporated into treatment wetlands? The answer to this question largely depends on outside factors from the design of the wetlands themselves by incorporating effective in town signage, tours, communication with the community, and other programs that integrate community support. The most applicable design feature to consider is inviting the community to the space by accommodating them and easing the associated trepidation humans have with wetlands. Designers truly do have the opportunity to affect perceptions which lead to changes in publicly held values. Another key aspect that allows communities to be less apprehensive towards wetlands is examples or pilot projects. When a model can be referenced it initiates understanding, interest and support for future projects.

An important aesthetic principle to reiterate is to create safe environments. As people are introduced into safe, educational, and aesthetically pleasing spaces the public will continue to have greater appreciation for those spaces. Wetlands are historically known for being problem areas associated with mosquitoes, poisonous reptiles, smells garbage, and generally noxious conditions. Although real challenges exist to overcoming these problems, the main challenge is changing long held human perceptions. Smardon, a landscape architect, said it this way, “So you say, you are going to use wetlands for treating wastewater! Sounds like trouble if you are going to try to be rational with the American cultural psyche” (Smardon, 1989:287).

One of the main fears of wetlands is the mosquitoes. They continue to be carriers of malaria, yellow fever, encephalitis (West Nile virus). Less known is the fact that treatment wetlands have no higher mosquito incident rate than other wetlands but may artificially extend the breeding season. Wetlands are commonly misunderstood as large breeding areas of mosquitoes and recommendations have been made to drain wetlands or at least not create new wetlands. While it is true that mosquitoes do lay eggs in standing water, draining wetlands may actually produce more mosquitoes due to the natural predators present in a healthy wetland ecosystem. Areas that are more problematic include isolated small puddles with no habitat available for natural predators.

Mosquito fish (Gambusia affinis) and aquatic insects, such as the dragonfly, damselfly larvae, and beetles naturally prey on mosquitoes. Low dissolved oxygen levels and thick stands of vegetation can limit predation. Mosquito fish are the easiest and most reliable mosquito population reducers. The fish can live in perennial flooded areas without any anoxic conditions. Deep water areas provide refuge for fluctuating water level conditions and cold weather.

Another concern is that wetlands also attract water moccasins (Ankistrodon pisivorous). However, no injury has ever occurred in a treatment wetland but the threat is real. Since many naturally wetland occupants are uncomfortable with human presence, conflicts don't often occur between wildlife and humans. Well placed and designed signage and well maintained paths can greatly reduce risk of injury.

Odor is a common objection to visiting treatment wetlands. Fortunately in a properly functioning treatment wetland, there is no more odor than natural wetlands. Within wetlands, most of the odor comes from the anaerobic conditions which produce a sulfur smell. These anaerobic areas can be controlled by the amount of BOD_5 and ammonia nitrogen loading into the wetland. Interspersing aerobic pools or channels and distancing these areas from circulation patterns can help with the natural hydrogen sulfide smell.

Another aesthetic theme that plays an important role in allowing the wetland to be appealing is neatness. Garbage is one of the most significant negative factors listed by preference surveys (Nassauer, 2004:757) (Benjamin, 1993). Efforts to reduce garbage can also lead to volunteering opportunities, community respect, and wider acceptance of the wetland.

A particularly applicable study performed on understanding the values placed on treatment wetlands in a community context was conducted by Thomas Benjamin in

1993. As a graduate landscape architect student at the University of California Berkley, he was interested how a 154-acre marsh in Arcata, California affected the community. Benjamin discovered the respondents felt that Arcata had been influenced by the marsh in the following ways: wide recognition to Arcata because the marsh is a "model" for other communities for improved wastewater treatment, increased tourism and revenue, increased open space and recreational opportunities, improved environment, and increased environmental awareness and education. The following list is created from the values stated by respondents in the survey (a more extensive summary of the Arcata marsh survey is included in the appendix) :

- *Aesthetics* – scenery/beauty, "good place," "nice place to visit and look around."
- *Restorative Environment* – peacefulness, serenity, relaxation, "leave worries behind," "immediate meditative release," "lifts spirits," "respite," "great sense of well-being," solitude.
- *Ecology*– wildlife, birding, environment/ecological.
- *Multiple Uses* – diversity of land uses, specific recreational activities, universality, wastewater treatment "it works."
- *Community* – community pride, "community enhancement," "community bonus," "asset for a small area," outside recognition/model, tourism, history, proximity/nearness, economic value.
- *Education* – educational/awareness, "tremendous educational value."

The Community Design Process

When human use of a treatment wetland is determined appropriate, the community should play an integral role in the design process. Experts and local citizens often see the same situation differently. This can be frustrating for both because there still exists scientific knowledge gaps for desired results. Also, incorporating public input can be difficult because the public never holds a single point of view. The public's perceptions are based on different experiences and knowledge. When voicing desires or needs for the wetlands there can be gaps between what is wanted and what is practical.

Questions arise about how much input the public has in the design process. Since the municipality is public domain, the public should have some leverage. However, this may change the paradigm from where a pipe or facility is placed, to how it is designed. This public interaction probably becomes new territory for municipalities. However, if the public feels that their needs are satisfied, then community support often increases the meaning and effectiveness of the process.

A meaningful exchange of ideas and information needs to be established. Extra costs into presenting design ideas in the complex science of wastewater and wetland ecology can be substantial. If designers feel threatened, they can often use their knowledge to withhold information or skew ideas. For example, using terms or processes that are complex or confusing or presenting ideas or pictures in a different light than known reality.

Although careful to keep the facts right, detail can be obstructive to communication. Pictures, perspectives, models, and computer simulations may be appropriate just as presentations of new parks would be given. Wetland cells, nodes, planned amenities, trails, existing areas can all be broadly represented. Plans should provide alternatives, keep the project within the bounds of feasibility, and offer several solutions that can be combined, altered or spliced together. The public should be given opportunity to give feedback. Instead of just 'no,' alternative solutions or ideas build instead of breakdown.

Public input should be sought after at the earliest point of the design process. This process can be initiated through working with existing community groups and networks such as bird watching groups or churches. Including outside input from the very beginning, starting with the program or design elements actually allows genuine impacts to be made. As designers view the design as a community space, they can effectively integrate the community through the design process as well as the actual design.

Education and Research

> "Wetlands have been described as living museums where the dynamics of ecological systems can be taught. No other system is more suitable for demonstrating such a broad range of ecological principles within a small area" (Hammer, 1989:355).

Human intervention begins with our water withdrawal directly from our streams and aquifers. After we use the water for our sinks, toilets, showers, factories, etc. we send the water to be treated by wastewater plants. After several processes of treatment we send it through treatment wetlands as a final point of polishing the water. This terminal point of human use of water can act as a powerful educational catalyst. Intrinsically this point where nature takes back what we've taken brings interest in water resources and human interaction with nature. Treatment wetlands are naturally well adapted locations for educational programs, interpretive signs or kiosks, or nature centers.

Education traditionally has been broken down into adult interpretation of the site and children education of the science of wetlands. Other facets of education that can often be overlooked or categorized outside education are the promotion of the site and its history, familiarizing the public with the ecosystem's functions and uniqueness, or opportunities for research and experimentation. Much of the public knows very little about wetlands, let alone treatment wetlands. This lack of knowledge and familiarity may transfer to people's negative perception of wetlands. The Arcata survey showed that the perceptions of the wetland often aligned with the familiarity of the site (Appendix, Review of Arcata Marsh Thesis).

Conclusion

Because wetland creation is so complex and often technical, research needs continue for successful future wetland creation efforts. Research such as the effects of secondary treated wastewater on amphibian mutation rates and other effects on the environment have major implications on further applicability of treatment wetlands. Also, if water budgets are known (which they usually are) they provide an asset to continued research within constructed wetlands.

CHAPTER 10

INTEGRATION OF PARKS WITHIN TREATMENT WETLANDS

Introduction

The idea of integrating parks within treatment wetlands is not new. Robert France suggested that as future principles of water sensitive planning and design are applied to treatment wetlands, they have the potential to become valued “multifunctional designed wetland parks” (France, 2002). Although this goal has been partially realized in projects such as the Green Cay Nature Center and the Arcata Marsh, it is far from common and still lofty.

The following list is a summary of thoughts presented earlier that add credibility to the idea of integrating parks within treatment wetlands:

1. The regional context of wastewater treatment facilities puts most treatment wetlands at a low elevation in the landscape with connected forest or other natural areas.
2. Communities are more environmentally aware of their surrounding, expect more environmental efforts, and are more aware of public funds than ever before.
3. The public is beginning to identify wetlands as a resource to be embraced rather than discarded.
4. Successful examples of treatment wetlands have created momentum for future projects.

5. Designers are more attentive to create public landscapes with higher functionality and more ecologic value.
6. A collaborative design environment between disciplines is becoming the more commonplace.

The beginnings of integrating parks with treatment wetlands inevitably came through a process of happenchance. After a treatment wetland was built, birds occupied the open water. When bird watchers desired access to constructed treatment wetlands, designers began to plan for the human factor. When the public began to have access to treatment wetlands, other passive recreational activities followed.

Natural wetland parks, or those that have not been intentionally manipulated to treat a point source discharge, present a relevant model to follow. Most wetland parks include only passive recreational activities and parks integrating more traditional recreational activities have been limited. They often include natural or restored wetland sites, paths, lookout areas, interpretive signage, possible facilities or centers, and parking. Integration with facilities such as nature centers, botanical gardens, arboretum, or trail system has also presented synergistic associations.

There are limits to how a park can be integrated into a treatment wetland. Since treatment wetlands attracted bird and other wildlife which can be extremely sensitive to any human presence, there must be a buffer or some other significant separation between the wetland and active recreational activities. Beyond just the presence of humans, increased noise and lighting can discourage healthy ecosystem development. The separation is not only required for concern of wildlife habitat, but for the concern of human safety. Someone retrieving a ball in the water may not be extremely aware of their surroundings while in the middle of a game.

Another limit includes public contact with wastewater. The EPA recommends that the public has no contact with secondarily treated wastewater. Extreme efforts have gone into creating barriers between the water interface and public at both the Green Cay Nature Center and the Wakodahatchee Wetlands with boardwalks, fences and heavy vegetation.

The size of the wetland and associated land affects how park uses may be integrated. Since larger areas generally attract more uses, larger parcels grant a greater amount of flexibility than a small one. The size of area also impacts the amount of habitat diversity and buffer areas from urban disturbance. In view of safety, habitat protection and the requirements that wastewater treatment wetlands present, integration of recreational activities should be included only after careful planning and consideration of avai1lability of adequate land area.

A sub-category of park integration includes art. Ecological art is expression of art forms in the landscape that emphasize the harmonic coexistence of human beings and nature. Treatment wetlands offer a unique environment for the expression of ecological art and present a unique palate to work within the manipulation of cells or large landscape forms. John Lyle stated, “If we can manifest the inherent elegance of ecological processes in visible forms, those forms will become symbols for the times” and will be “meaningful, even beautiful, in terms of process and context” (Lyle, 1996:45).

Examples of such art include Rudolf Stiener Seminariat's sculpture that cascades and aerates effluent from the community of Jarne, Sweden, a community of more than 200 people (Hough, 1984). Art within an ecological landscape such as a treatment has a significant promise to evoke expression and deep meaning. Aesthetic significance of ecological processes can be expressed effectively through art or concealed landscape forms.

Examples of Integrated Parks

Integration of parks and park functions within wastewater treatment wetlands includes more than just adding programmed recreational activities within a given piece of land. The following projects show that a myriad of possibilities exist when adding human functionality to a park. Although some of the projects only include constructed wetlands, the principles of incorporating treatment wetland into a park setting still apply.

Warren G. Magnuson park is a 350 acre park in Seattle that has multiple existing wetlands on site. The existing park contains two baseball fields, tennis courts and other active recreational areas with scattered vegetation covering most of the park. The vegetation consists of wetland remnants and agricultural fence remnants. Plans for the park include significant wetland restoration, vegetation management, and the addition of several active recreational areas such as baseball, soccer and multi-use fields. The park is able to include these multiple functions through substantial planning, modest buffers, and a large parcel of land. Water quality marshes (instead of habitat areas) were employed as a strategy to create functional buffers from active recreational areas. The plan illustrates how a large park can include multiple functions including active and passive recreation, education, wetland restoration, improvement of water quality, and habitat creation.

The Northside Park in Denver, Colorado provides an example of integrating existing public utilities within a designed park. The park was built on an abandoned wastewater treatment plant and the design incorporated remnant pieces of the existing plant to create historic significance, reduce demolition costs (an estimated 30%), and allow unique structures to acts as elements of exploration and reflection within the park. Through “designing by subtraction,” concrete walls, flumes, aboveground pipes and other parts were removed or modified to add interest and context to the park. Also, since the park was located at the out-fall of a regional drainage basin into the South Platte River, the site also incorporated wetlands for wildlife habitat restoration within a built stormwater detention facility. By day lighting originally mundane treatment plant structures, this project shows how the public can take interest in wastewater functions and shows that art can strongly tie treatment processes to public spaces.

Relatively little experimentation has tried incorporating art with created wetland forms. Oregon’s A-mazing garden is one example of an ornamental wetland. The garden was created through the cities requirement to meet water quality standards and an association looking to start a botanical garden. A landscape architecture firm designed the treatment wetlands to create a landform that was artistic and appealing. In form, the project seems to break most of the principles of hydraulic efficiency but the nutrient removal is adequate. This park has the potential to create greater credibility for treatment wetlands to be used as outlets for art or application of other creative design alternatives.

Conclusion

Integrating park functions within a treatment wetland is not a practical objective for all projects. However, when the large land requirement can be met, there are significant opportunities and benefits that a fully integrated park system can bring to a community. Combining uses can create a more enjoyable and frequented area that utilizes the land efficiently.

CHAPTER 11

SUMMARY AND RECOMMENDATIONS OF REVIEWED PROJECTS

Introduction

Seven treatment wetland projects that include design elements for human use were chosen for review. Sites chosen are designed for human use, have municipal wastewater input, are constructed wetlands, and are over fifty acres in size. The Carolina Bay Wetland and Wakodahatchee Wetlands only meet three of the listed criteria but are included for their unique characteristics. Two site visits were made to the Phinizy Nature Swamp the fall of 2004 and the second week of March in 2008. The Viera Wetlands and Orlando Easterly Wetlands were visited the second week of March in 2007. And the following sites were visited (or revisited) the second week of August, 2007: Bear Bay Wetlands, Viera Wetlands, Orlando Easterly Wetlands, Indian River Wetlands, Wakodahatchee Wetlands, and Green Cay Nature Center. The projects are presented in the order of their proximity to Athens, Georgia.

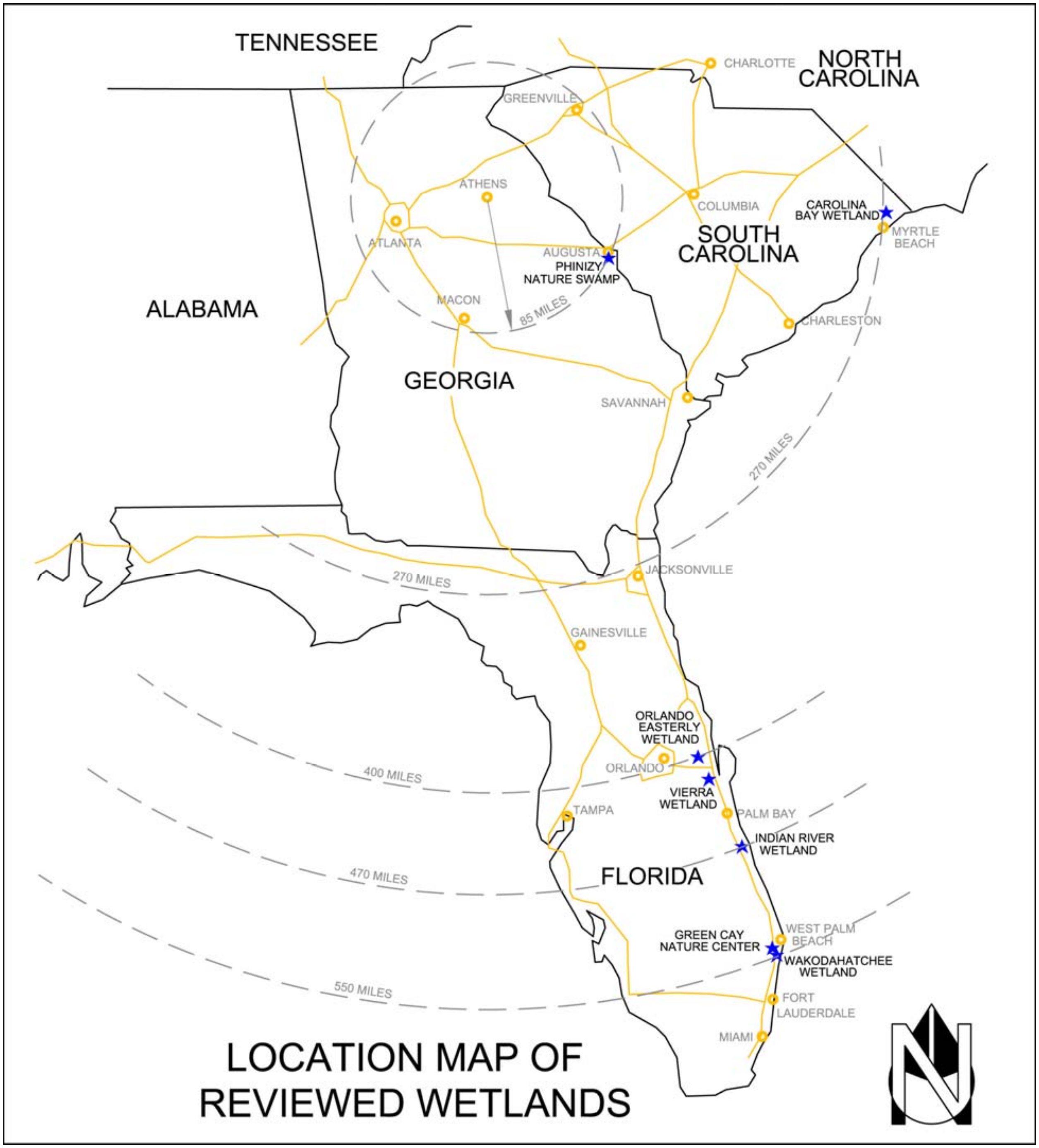

Figure 11.1 – Location Map of Reviewed Wetlands

(drawing by author).

A general review of gathered information is reported and conceptual design recommendations proposed. In some cases, general assumptions were made or estimated. The recommendations are conceptual and generally demonstrate simple alterations that would increase aesthetic pleasure. Each wetland is rated for its effectiveness in attracting human use compared to amount of land. Issues such as specific site history, community context, design restrictions or regulations, and budgetary constraints are not addressed.

The recommendations follow a proposed design protocol for increasing general visual aesthetic principles in existing projects. The protocol was developed in response to observations and successes extrapolated from the reviewed sites. The protocol assumes that the treatment wetland cell arrangement is already designed or built. The proposed steps to the design protocol are:

1. Lay out the circulation patterns within the cell matrix, (including possible boardwalks or built structures) to, near, and possibly over any extremely visually interesting or sensitive areas.
2. Identify natural focus points and nodes.
3. Identify spaces and sight lines that present unique viewing opportunities to identified nodes thus create a motive for visiting the destination.
4. Design appropriate structures to create focal points and nodes (trees, shrubs, overhead structures, lookouts, benches, etc.).
5. Reinforce the spaces and sight lines to the nodes by using vegetation, additional structures, and/or manipulating berms and adjacent land forms.

These steps assume that the wetlands can incorporate vegetation and vertical structure and that the aesthetic or regional context accommodates such structures. Although these assumptions are not true for all projects, these steps are relevant to all of the reviewed projects.

Through this five step process, many of the aesthetic principles were applied through attention given to the creation of spaces and the visual experience. By identifying and signifying circulation pattern and nodes, visitors are better able to understand the site. Effective signage, maps, and treatment of pathways are more readily achieved as well. Reinforcement of the nodes, spaces and sight lines create distinct spaces, views and regions. The four Kaplan principles are all enhanced as well. As the views and regions are better defined, spaces are more apparent, depth and richness increased, spaces more distinctive, and the landscape offers more interest.

Phinizy Nature Swamp

Figure 11.2 – View Looking Out on the Natural Swamp Area

(Photo by Author).

The Phinizy Nature Swamp is located about 6 miles south of the center of Augusta, Georgia and gives tertiary treatment to effluent from the cities only main wastewater treatment plant. The treatment wetlands were built mainly in response to high ammonia levels that eventually flowed into the Savannah River. The project has been led by Dr. Gene Eidson since its inception and under his direction the clear foci have been research and education. Under the auspices of Southeastern Natural Sciences Academy, education and research efforts conducted on site and at other wetlands have benefited the local and research community (History of the Augusta Phinizy Nature Swamp, 2004).

There are multiple wetlands associated with the site including swamp areas, natural floodplain/riverine wetlands, and constructed treatment wetlands. The stream intersecting the site, Butler Creek, has historically received different levels of untreated wastewater and significant efforts have been made to clean up associated swamp. These efforts have engendering significant community support and exposure to the wetlands. Even though much of the trail system on the site consists as treatment wetland berms, most of the hiking activity actually occurs within the natural forested areas. Instead of pipes, the treatment wetlands utilize an elevated distribution canal which effectively allows some treatment to occur as it is conveyed to individual cells. The canal presents act as a significant object of reference within the treatment cells.

Figure 11.3 – View of the Chain Link Fencing Around the Distribution Canal (Photo by Author).

Figure 11.4 – View of Lush Vegetation Within a Typical Treatment Wetland. Notice the Tree Line in the Background (Photo by Author).

Although the treatment wetlands do enhance the site functionally for treatment and research, aesthetically they contrast the lushly vegetated and canopied stream areas. Visually, this contrast creates attractive open framed views of the marsh.

However, the transition between the flat marsh and vertical tree line is unnatural and visually abrasive. The circulation map only shows paths on berms directly adjacent to natural wetlands. Also, there are few compelling visual landmarks that invite a visitor to explore the treatment wetlands.

Table 11.1 – Phinizy Nature Swamp Information Sheet

Location	1858 Lock and Dam Road, Augusta, GA 30906
Acreage	1,100
Acreage of Treatment Wetlands	Approximately 400
Built	1996 to 2005
Cost	10 million
Design Team	Unknown
Source of Waste	Augusta's James B. Messerly Waste Water Plant
Amount/Type of Waste at Inflow	32 MGD, Secondarily treated wastewater
Hydrology	Flow through
Discharge	Into local stream
Management	Local Wastewater Authority in collaboration with Southeastern Natural Science Academy
List of Existing Amenities	Nature/Education center, multiple view stands, foot bridge, multiple paths
Estimated Number of Annual Visitors	40,000
Educational Programs	Multiple
Estimated Number of Annual Students	45,000
Student use Per Acre Per Year	112.5
Visitor Use Per Acre Per Year	100.0
Total Human Use Per Acre Per Year	212.5 (85,000 total)

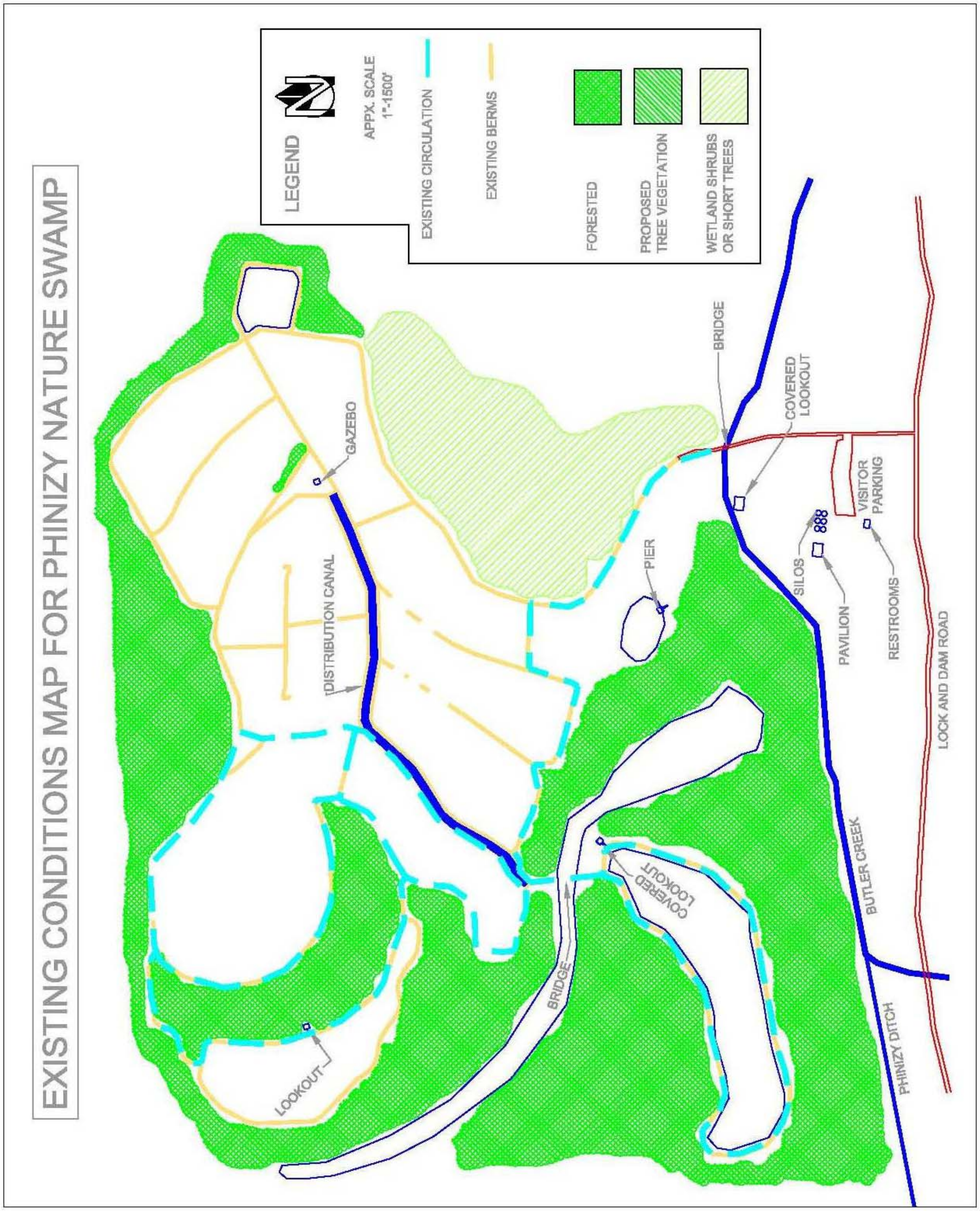

Figure 11.5 – Existing Conditions Map for Phinizy Nature Swamp (Drawn by Author)

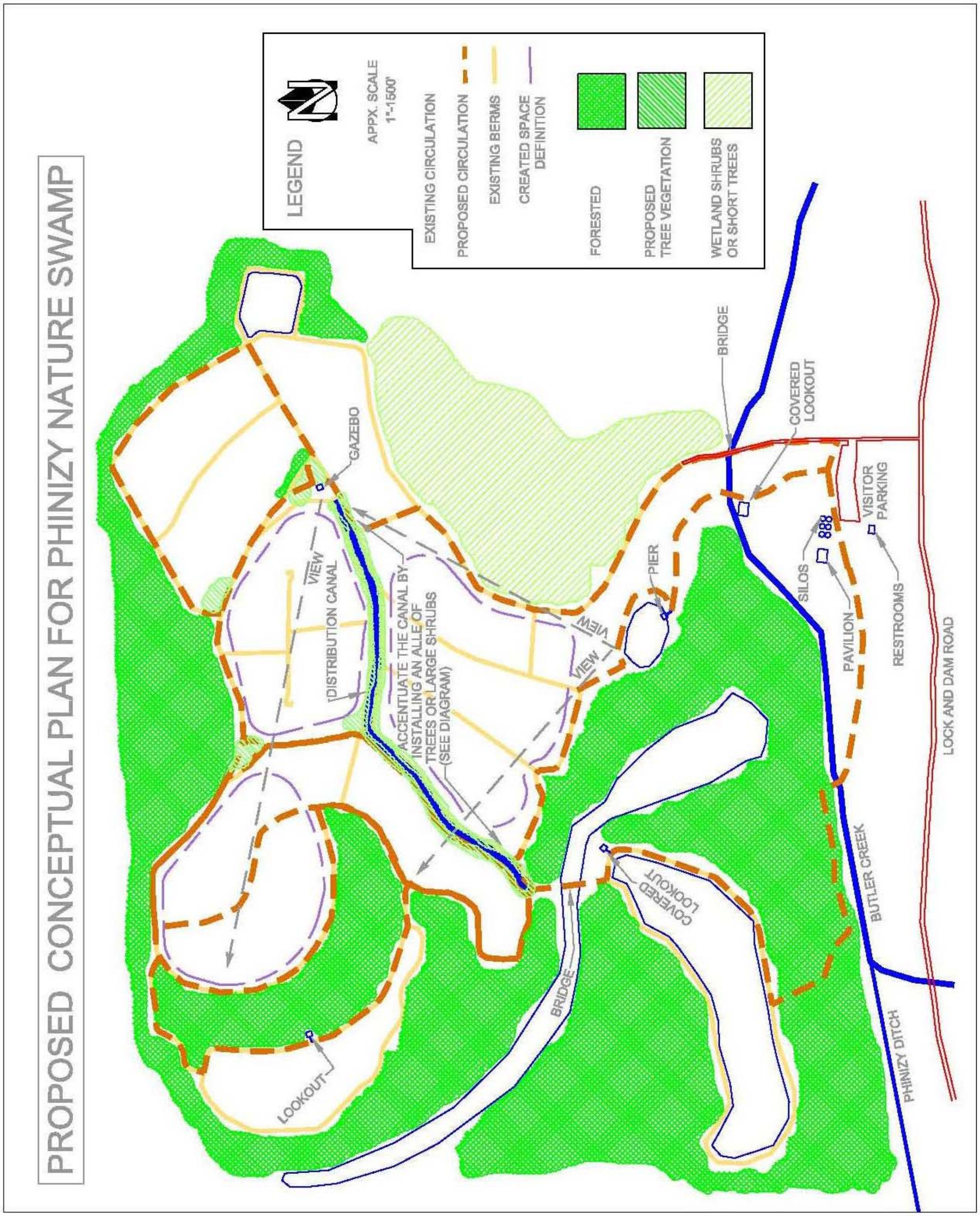

Figure 11.6 – Proposed Conceptual Plan for Phinizy Nature Swamp (Drawn by Author)

Conceptual recommendations include increasing aesthetic appeal by creating a peripheral circulation around the treatment wetlands and placing nodes to provide shade, spaces and a variety of views. The design of linear segments of planned trees would create semi-enclosed spaces between the periphery and the heavily vegetated swamp areas which would articulate the background. The trees would also create interest and spatial diversity for hikers.

Carolina Bay Wetland (Bear Bay)

Figure 11.7 – View of typical boardwalk within Bear Bay (Photo by Author).

The Carolina Bay project was originally a pilot project. To begin the project, Bear Bay, one of four Carolina Bays was used because it had been largely disturbed and planted in pine in the mid-1970s and was seen as a good testing ground for inputs of secondarily treated wastewater. After a year of piping and careful monitoring of the municipal effluent into the bay, the wetland's ability to remove constituent levels was found sufficient to proceed. Federal grant funds for innovative wastewater treatment were secured and planning for all four bays was conducted.

The original plan for the facility included creating a wildlife preserve and an interpretive center. The wildlife preserve was created but the center was not. Funding for the plans of the interpretive center were made available from the grant but no funds were allotted to actually build it.

Figure 11.8 – View of Visitor Parking and Entrance Building (Photo by Author).

There are clear signs on the highway indicating a bird watching scenic area. When first arriving visitors are greeted by an old building and a faded bird watching sign that states below it "Visitors must report to the main office upon arrival" (See Figure 11.9).

Figure 11.9 – Bird Watching Welcome Sign (Photo by Author).

Over the last five years, there have been very few public visitors. Also, due to safety concerns having to do with the local bear population, visitors were required to sign paperwork releasing the municipality from liability. Personnel within the main office expressed frustration at the signs directing people here because the boardwalks are not well maintained and they perceived a significant liability issue.

Both North and South Carolina contain scattered Carolina bays. Horry County, South Carolina has one of the highest concentrations of these features. Since the particular region is unique, it contains multiple teaching opportunities. There are no other areas that have such an abundance of bays, or elliptical imprints on the land. Also, since the Carolina Bays are natural wetlands, views or vistas are naturally more complex with existing stands or native trees and shrubs and some planted trees. This site offers rich geologic history, a complex natural wetland system, and a wonderful early example of the use of treatment wetlands. Yet the amenity is completely unknown to the surrounding communities.

Table 11.2 – Carolina Bays Information Sheet

Location	Water Lily Road, Little River, South Carolina
Acreage	700
Built	1987
Cost	Unknown
Design team	CH2M HILL
Source of Waste	George R. Vereen Wastewater Treatment Plant
Amount/Type of Waste at Inflow	Capacity to treat 2.5 MGD (due to technology upgrades, wastewater is not regularly introduced into treatment wetlands), Secondarily treated wastewater
Hydrology	Carolina bays
Discharge	Infiltration
Management	Grand Strand Water and Sewer Authority, George R. Vereen Wastewater Treatment Plant, Peter Horry Wildlife Preserve
List of Existing Amenities	Extensive boardwalks (4 – 4.5 miles)
Estimated Number of Annual Visitors	< 20
Educational Programs	None
Human Use Per Acre Per Year	0

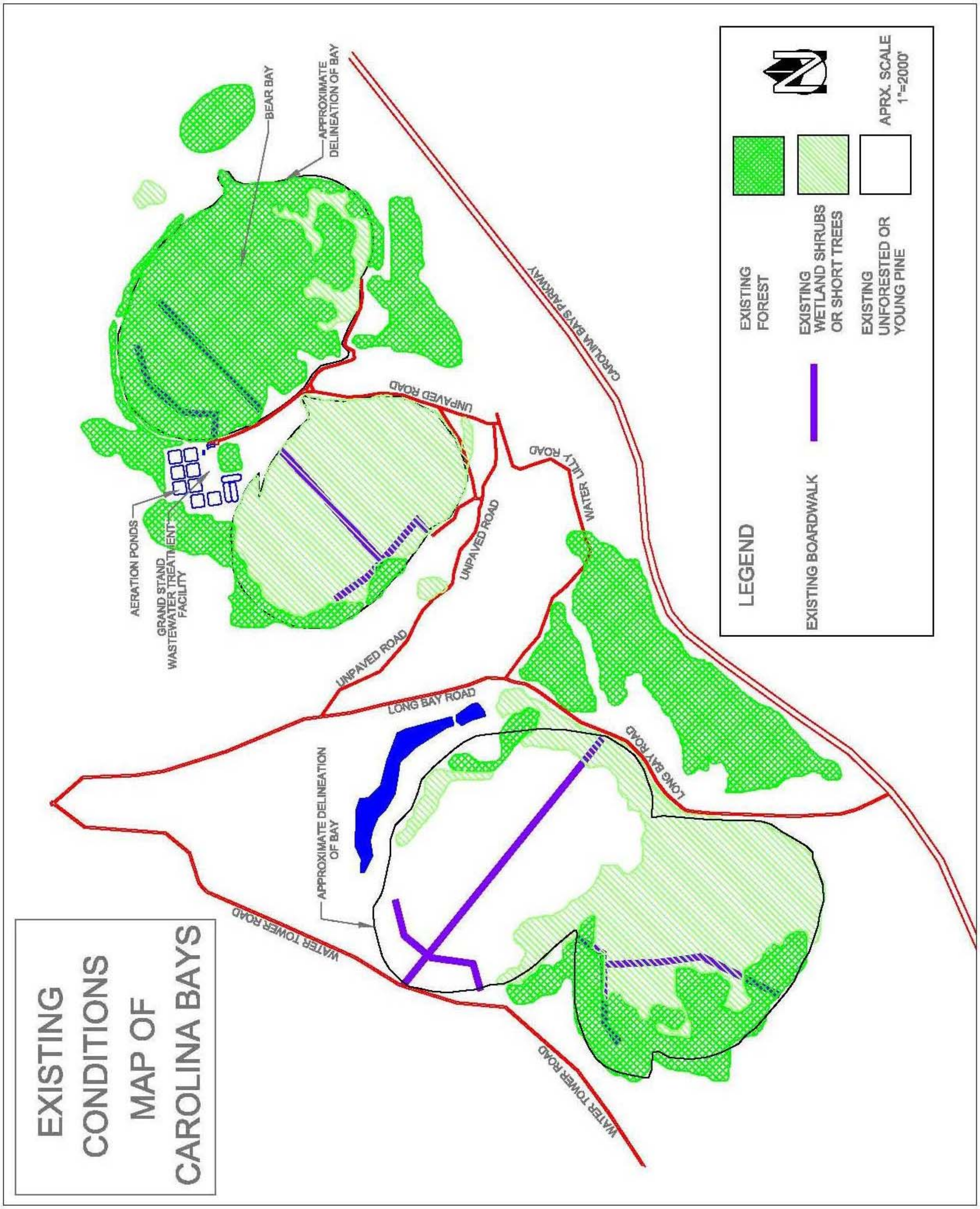

Figure 11.10 – Existing Conditions Map of Carolina Bays (Drawn by Author).

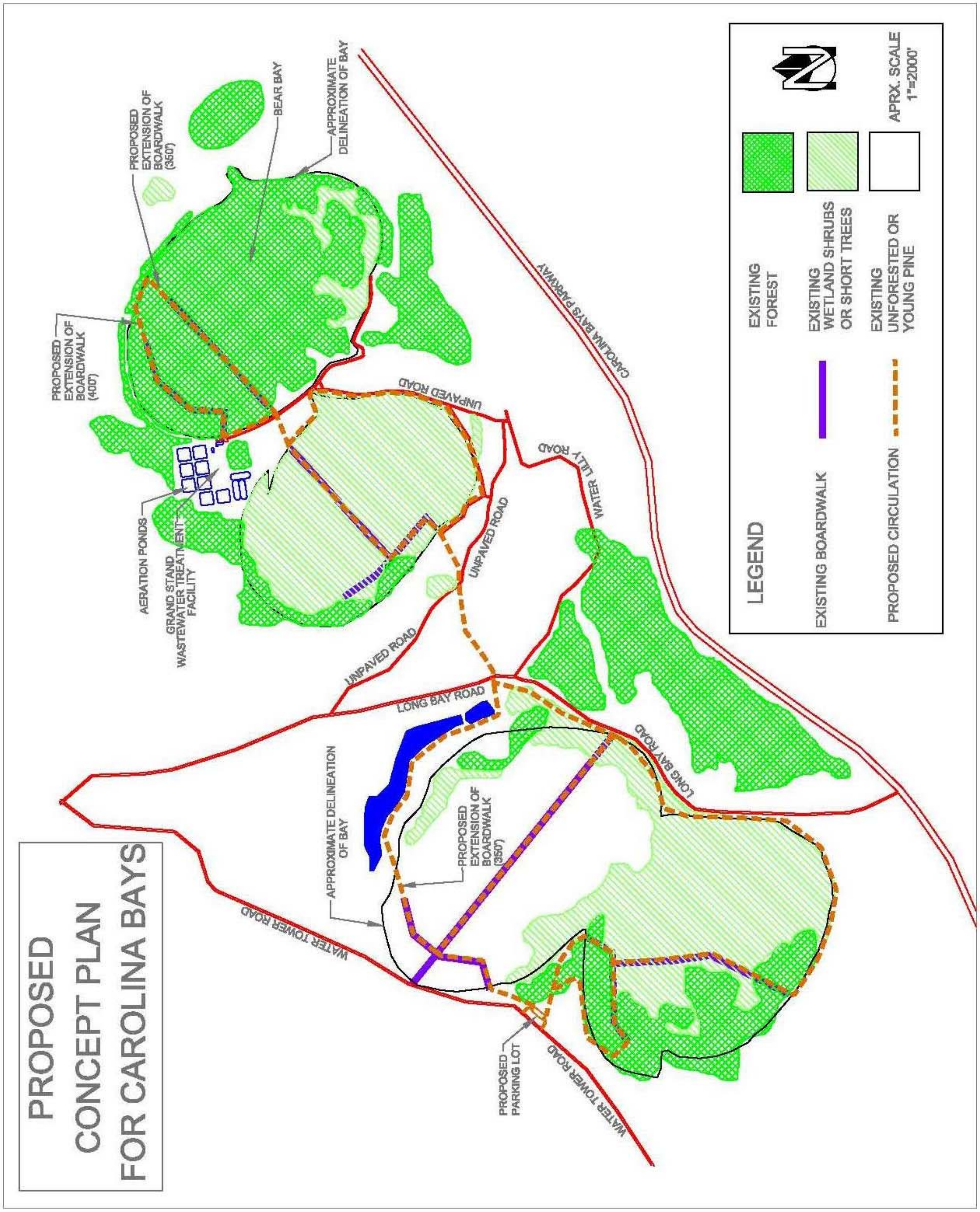

Figure 11.11 – Proposed Conceptual Plan for Carolina Bays (Drawn by Author).

The prime recommendation for this project would be to increase connectivity of trails and boardwalks and to develop a circulation plan. There are multiple boardwalks built for maintenance but small alterations would allow multiple loop trails to be attained. The current boardwalks provide no nodes or areas to rest or take in the scenery. Widening the boardwalk at points, adding benches and handrails in these areas would greatly increase human usability.

This site has the most potential of all the sites studied for interesting a large number of visitors with only minor changes. With only a few boardwalk and pathway extensions, the site would offer miles of public trails and naturally beautiful views. The land has been set aside for public use and is not being used. A largest hurdle to jump would be safety concerns.

Orlando Easterly Wetlands

Figure 11.12 – Map of Orlando Easterly Wetlands Park (Park Pamphlet, Author Unknown).

The Easterly Orlando Wetlands provides tertiary treatment to much of the wastewater from northeastern Orlando communities. The Iron Bridge Regional Water Reclamation Facility is located northwest of the wetlands with effluent from the plant being pumped approximately 13 miles. The site was originally wetland prairie with hardwood swamps and hammocks. Before the treatment wetlands were built the land had most recently been used for cattle grazing.

The Easterly Orlando Wetlands may be the largest treatment wetland designed to accommodate human use in the United States. The wetland includes 17 cells, 18 miles of berms, 410 acres of mostly cattails and bulrushes, 380 acres of mixed emergent and submergents, 400 acres of hardwood swamp, and a 75 acre created lake used for berm creation. Many existing trees were left and provide habitat for roosting birds.

Figure 11.13 – Sandhill Cranes Sauntering on a Berm Separating Two Cells (Photo by Author).

The original plan was formed by the joint efforts of Robert C. Haven and Thomas L. Lothrop or the City of Orlando, Alex Alexander of the Florida Department of Environmental Protection, and Phillip E. Searcy of PBS&J, Inc. The project's official name is "Orlando Easterly Wetlands Reclamation Project" and was an early experimental project to treat large amounts of wastewater. The plan's secondary objective was to provide wildlife habitat. Design elements for human use were also incorporated. Although the original plans for the wetland included multiple boardwalks, it currently only has boardwalks at the influent point.

Figure 11.14 – Overhead View of the Influent Point (Sees, 2006)

Figure 11.15 – Close-Up View of the Influent Point (Photo by Author).

The wetlands include significant background tree canopy. The spaces created from the internal trees and outlying forest areas within the park do a fair job of creating large spaces that reward the hiker. Both existing native wetland trees and natural succession growth have established themselves at the high points of large cells, where a significant elevation drop occurs allowing the top of the cell to be free from permanent inundation.

Strengths of this site include the creation of spaces with significant path creation with the variation of berms and natural forested wetlands. Also, even though the berms are built for vehicular travel, they are quite wide and the slopes are very gradual. The entrance for the site includes an interpretation center, restroom, pavilion, and an open green space for recreation. The combination of these amenities has created one of the first US wetland parks.

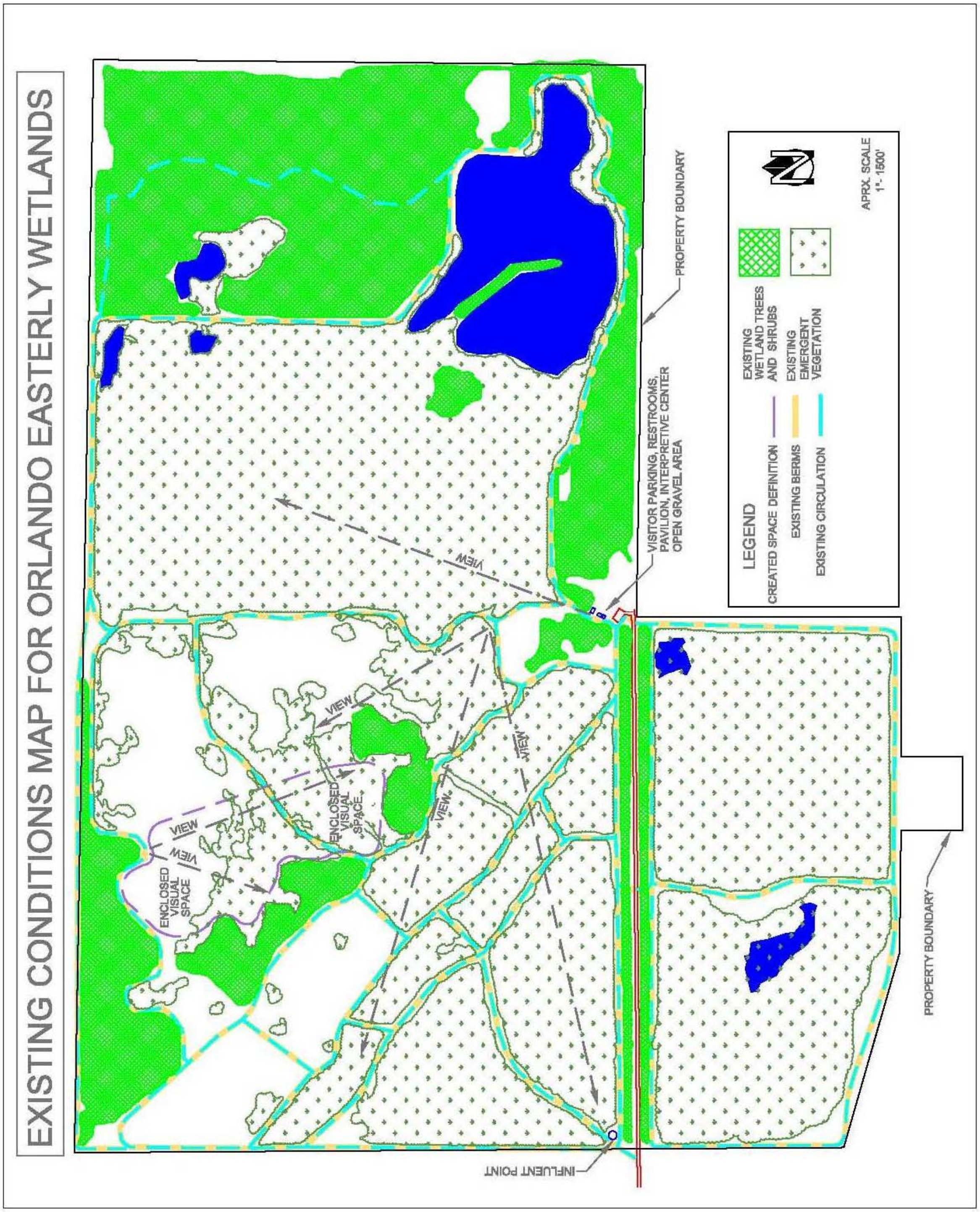

Figure 11.16 – Existing Conditions Map for Orland Easterly Wetlands (Drawn by Author).

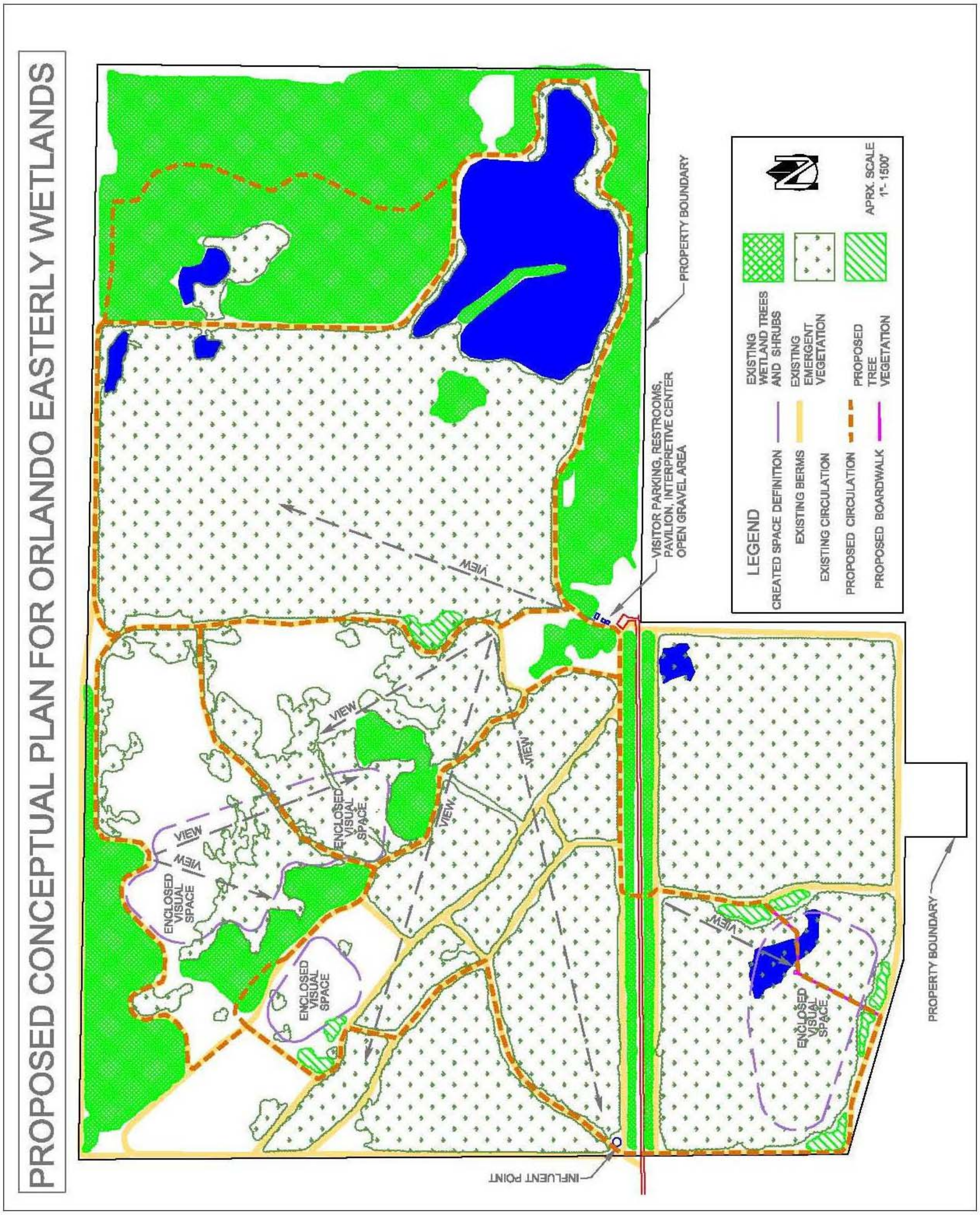

Figure 11.17 – Proposed Concept Plan for Orland Easterly Wetlands (Drawn by Author).

Table 11.3 – Orlando Easterly Wetlands Information Sheet

Location	25155 Wheeler Road, Christmas 32709
Acreage	1,650
Acreage of Treatment Wetlands	1,190
Built	1987
Cost	22 Million
Design Team	PBS&J
Source of Waste	Orlando's Iron Bridge Wastewater Plant
Amount of Waste at Inflow	24 MGD
Hydrology	Flow through
Discharge	Into local stream
Management	Orlando Wastewater Management
List of Existing Amenities	Open picnic pavilion, one view tower, multiple trails, one outdoor classroom
Estimated Number of Annual Visitors	12,000 in 2004
Educational Programs	None
Human Use Per Acre Per Year	10

Recommendations for the site include create more shade and rest areas within the treatment wetlands. Although there are many interesting spaces to explore, relatively few benches are available. The best solution would be to identify node areas and then reinforce those areas and views with benches, shade and vegetation. As was mentioned earlier, there are very few boardwalks in these wetlands. An accessible boardwalk near the parking area would allow visitors to immerse themselves into the center of the wetlands. Although there is multiple signage and interpretation at the parking areas, there could be more interpretive signage throughout the site to explain significant elements or history of the site. Also, the lower part of the site on the other side of Wheeler road (see Figure 11.12) offers no real reason for exploration. Application of the design protocol would increase the aesthetic appeal of this area.

Viera Wetlands (Brevard County)

Figure 11.18 – View from Lookout Tower over a Wetland Cell to the Wastewater Treatment Plant (Photo by Author).

The Viera Wetlands are unique to this review in that they are the only wetlands with circulation completely designed for vehicular traffic. The berms are very large, (35 to 50 feet wide) conducive to automobiles and the vehicular scale. Although giving convenient access to visitors by creating a car-oriented experience seems to work well for the visitors, this type of setting may conceal much of the experience that the site has to offer.

The berms sit higher above the water than any other site. The slight difference in berm height and slope makes a significant difference in perceived connection to the wetland. Visitors may sense a decrease in intimacy or detachment from the wetland.

Figure 11.19 – A Favorite Makeshift Parking Area Next to a Lookout

(Photo by Author).

Although the site has some visual variety to offer through planted habitat islands, the design of the wetlands doesn't create any distinct spaces. The island vegetation establishes some visual interest, but most views of the wetland are directly accessible from anywhere on site. There is little mystery or change in the spaces through the experience of walking and thus little reason to walk. Entering the site as a pedestrian, the scale seems overwhelming. At 200 acres the site is fairly large; however, the scale is exaggerated because there are no vertical structures to contain or define the boundary edge. Because the site seems so exposed and automobile are allowed to access most of the site, the natural reaction of most visitors is to gain quick and immediate access to the lookouts and reject the pedestrian experience.

Table 11.4 – Viera Wetland Information Sheet

Location	10001 Wickham Road, Melbourne, Florida 32940
Acreage	200
Built	Early 90's
Design Team	Wetland Solutions, Inc.
Type of Waste at Inflow	Secondarily treated wastewater
Hydrology	Flow through
Discharge	Into local canal
Management	Brevard County Utility Services
List of Existing Amenities	Two lookout towers, one gazebo, multiple benches, no paths (designed for automobiles)
Estimated Number of Annual Visitors	60,000
Educational Programs	None
Human Use Per Acre Per Year	300

The main recommendation is to define a pedestrian circulation route and then enhance it with the creation of spaces. This gives the visitor an alternative with something to offer for the person that gets out of the automobile and experiences the place through moving through it. Also, adding boardwalk experiences over some of the emergent vegetation allows visitors to explore and immerse themselves in the wetland.

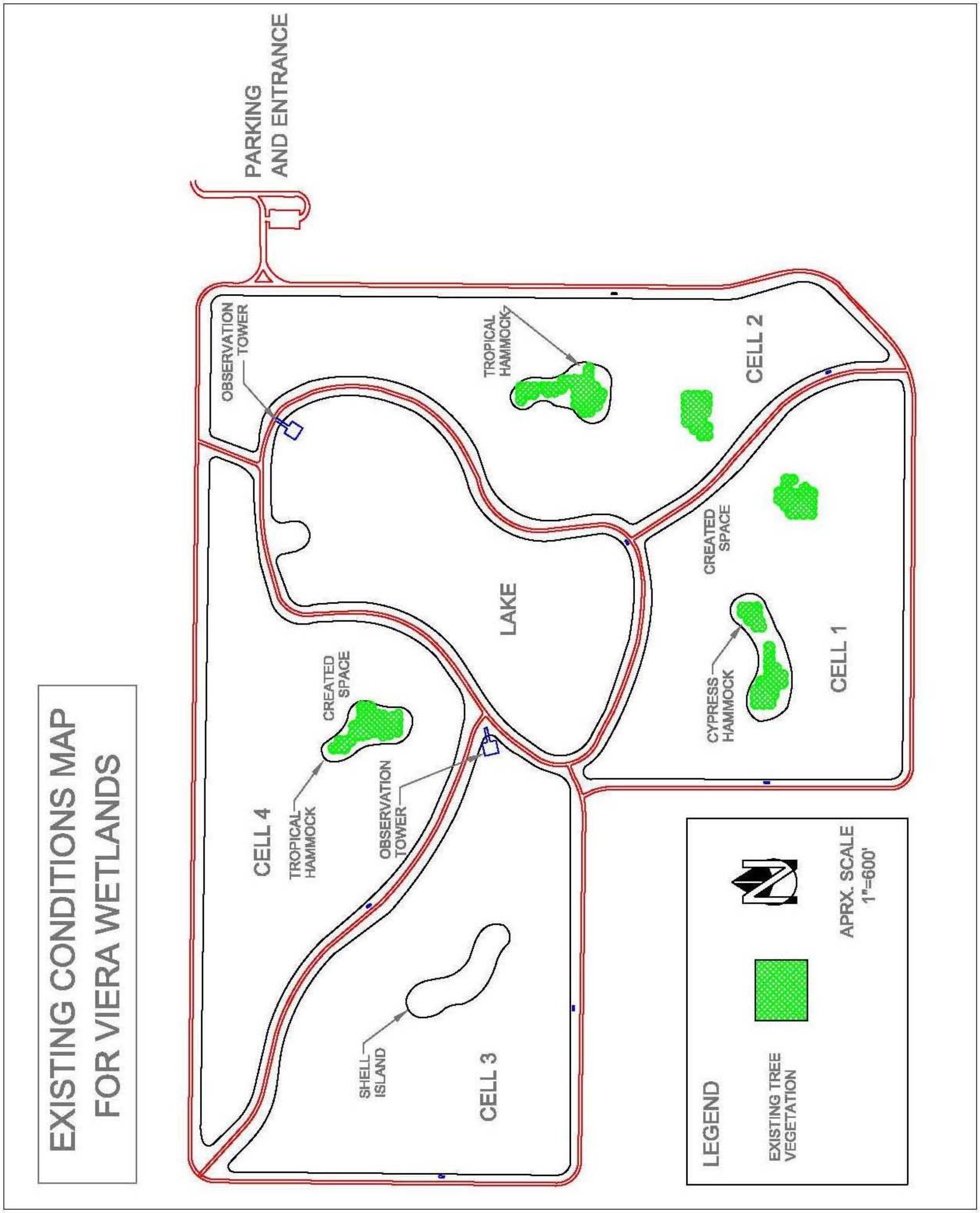

Figure 11.20 – Existing Conditions Map of Viera Wetlands (Drawn by Author).

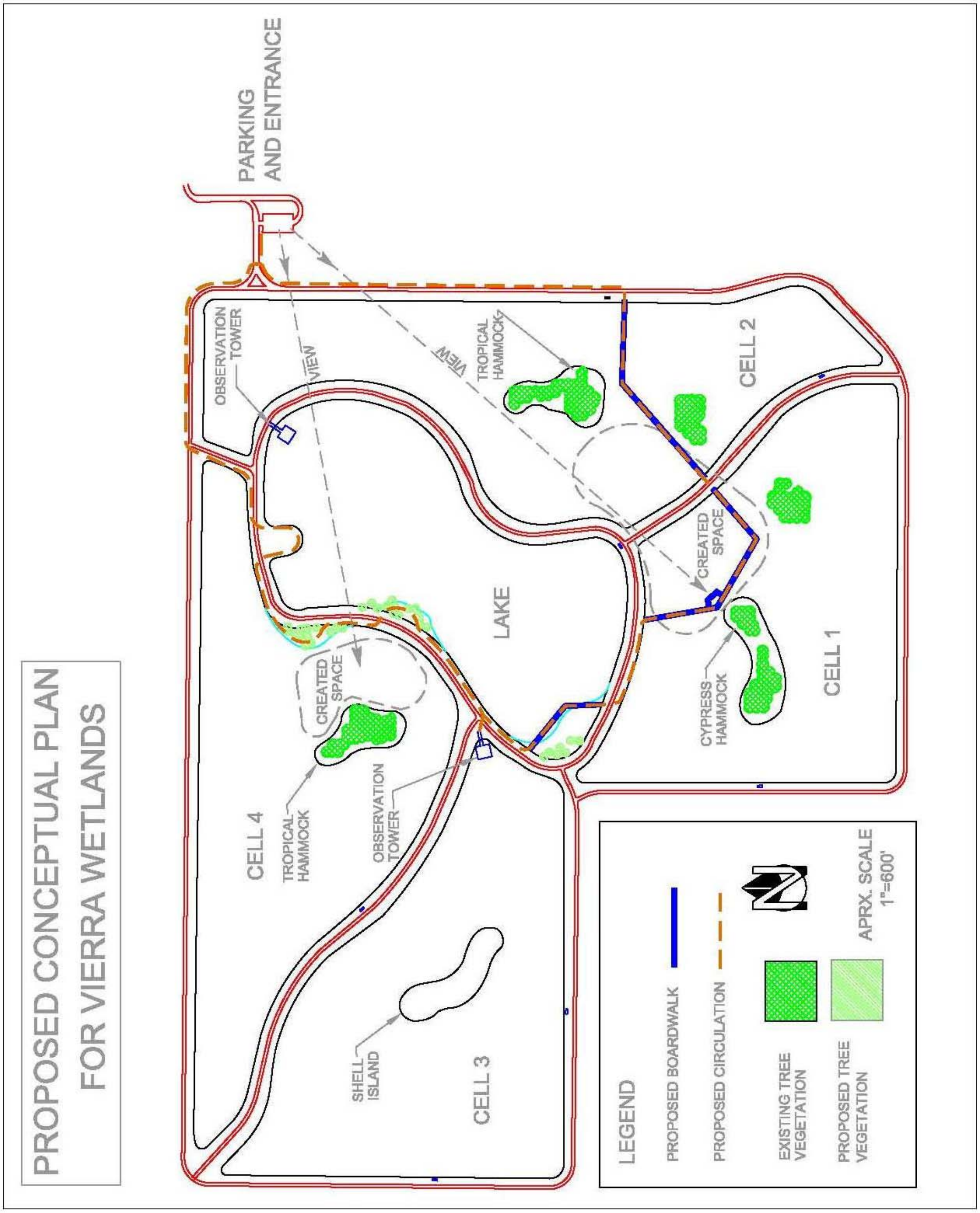

Figure 11.21 – Proposed Conceptual Plan for Viera Wetlands (Drawn by Author).

Indian River Wetlands

Figure 11.22 – View to the Existing Tree Grove from the Gazebo. Notice How Visually Interesting the Vegetation, Shrubs, and Background Trees can be. (Photo by Author).

The Indian River Wetlands resides west of Vero Beach, Florida. The location is fairly removed from urban areas; however, the wetlands are plainly visible from Interstate 95. Signage for the wetlands is plainly posted along the main street off of the interstate. One unique characteristic of these wetlands the smaller, more intimate sized berms which match the human scale better than other larger berms. The drawback is that they don't support all maintenance equipment. The height of the berms is about 2.5 feet higher than the regular water surface as opposed to nearly seven feet at Viera wetlands. Another distinctive element of this wetland is that the grassed entrance is quite pronounced with trees lining the drive and berms on both sides.

The author's experience in visiting the wetland is a telling one. I entered the site and the first sign I saw was a "Stop, authorized vehicles only" sign.

Figure 11.23 – "Wetland Parking" Sign Leaning Up Against a Tree with a Locked Sign In Station and Barely Visible Wood Parking Stops (Photo by Author).

So I stopped and parked on the grass. After I had gotten out of my vehicle I noticed a plastic locker and I walked up to it to figure out what it was. There wasn't anything in it so I looked down the long road and began walking. After I walked a third of a mile, I found a small building and went in to get permission to visit the wetlands and sign-in. As I talked to the two plant workers, they asked me where my car was and then began to laugh as they realized that I had walked all the way down the road. Apparently there were signs further down the road that pointed to a visitor parking area behind the facilities and closer to the wetland.

After talking to the plant workers, I wandered trying to find the trail that was supposed to lead to the boardwalk. I didn't find the trail, so I just started walking down berms in the general direction that the workers had told me to go. When I finally made it to the boardwalk I found the initial 300 feet ran parallel to and 15 feet of a berm to a lookout area.

Figure 11.24 – Boardwalk 15 Feet Beside a Berm (Photo by Author).

There are about 1,225 linear feet of boardwalk in all. The boardwalks, benches, and lookout were all very old and dilapidated. Also, weeds were growing over the wood at points. The view from the gazebo area, however, was beautifully situated near a small grove of large wetland trees. Having all the designed human use structures focused upon the only substantial tree vegetation in the wetlands is instructive. However challenging it was to get there, the end result was worth it in my estimation.

Figure 11.25 – Overgrown Vegetation at End of Boardwalk (Photo by Author).

Figure 11.26 – View of Gazebo from Another Boardwalk with Interstate 95 in the Background (Photo by Author).

The signs restricting access to the road were there due to current expansion of treatment plant. As I left, I realized that there were bumper stops in the grass for parking stalls and the plastic locker was where the visitor signup sheet was supposed to be. However, no signs, paths or information were available at that point to let a visitor know where to go or to inform them about the site. Admittedly, most of the confusion initiated from dealing with the current construction.

The Indian River Wetlands provides a substantive example of land use efficiency for the treatment wetlands but not as much land efficiency outside the planned wetlands. The drawing shows how the site could easily accommodate the existing treatment wetlands, wastewater plant, future growth and a 20 acre park if the site had been designed differently.

Table 11.5 – Indian River Wetlands Information Sheet

Location	8490 8th St, Vero Beach, Florida 32968
Acreage	215
Built	Early 90's
Type of Waste at Inflow	Secondarily treated wastewater
Discharge	Into local canal
Management	Indian River Water Authority
List of Existing Amenities	One lookout, a gazebo, and a boardwalk
Estimated Number of Annual Visitors	<500
Educational Programs	None
Human Use Per Acre Per Year	2.33

The proposed plan shows how with minor changes this park, having extremely high visibility from the freeway, could present this region with a valuable community asset. The conceptual changes assume of designing from scratch and are not meant as a retrofit. The recommendations include changing the entrance to the bottom of the site to better utilize the slope of the site, adding peripheral circulation, and creating internal spaces and nodes. By following the general design protocol, this site can clearly include very interesting spaces, motion, depth of views, and interest from the interstate.

Figure 11.27 – Indian River Existing Conditions Map (Drawn by Author).

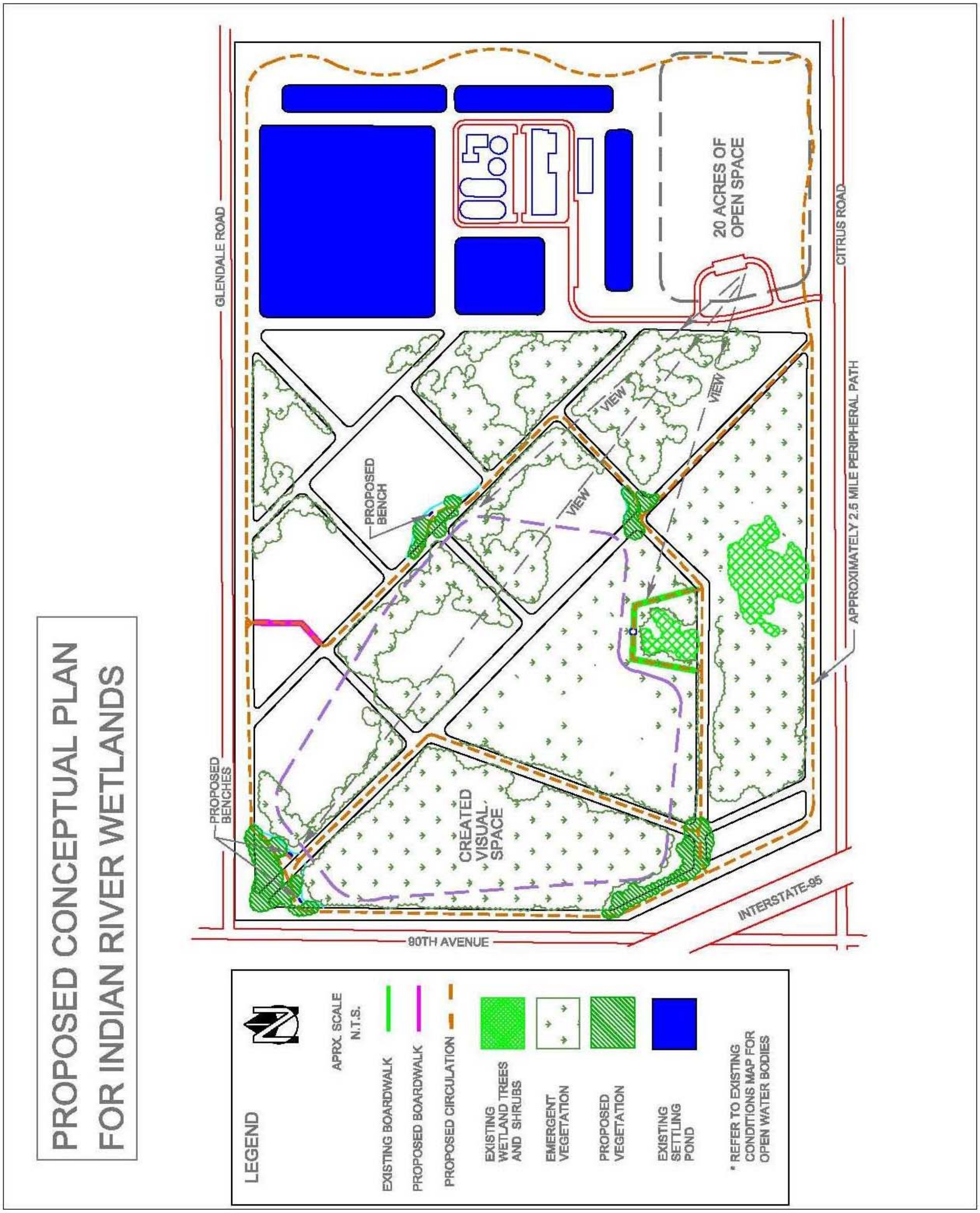

Figure 11.28 – Indian River Proposed Conceptual Plan (Drawn by Author).

Wakodahatchee Wetlands

Figure 11.29 – Overhead View of Wakodahatchee Wetlands (Knight 2007)

The name 'Wakodahatchee' means 'created waters.' The Wakodahatchee Wetlands is probably the most visited site per acre in the southeastern United States. This is easily credited to the construction of an extensive boardwalk system that was estimated at $600,000 (Knight 2007). The wetlands exhibit an amazing diversity of views, spaces, and textures. Probably the most stated reason for visiting is bird watching. However, the experience is enhanced by rich vegetation, other wildlife, abundant interpretive signage, and adequate shade and sitting areas. The community has truly embraced this wetland as well. Pictures from the wetland are posted on multiple websites; a monthly tour is conducted every second Tuesday at 9:00 A.M. and also every third Wednesday at 4:00 P.M. during winter months.

Figure 11.30 – View of Transversing Boardwalk and Attached Gazebo (Photo by Author).

Figure 11.31 – View of Boardwalk, Bench and Engaged Visitors (Photo by Author).

By creating many individual spaces and views, the small wetlands exude a sense of a much larger place. Berms heavily vegetated with trees at the entrance to the wetlands are used effectively in buffering the nearby water resources building and large tanks. Within the wetland, the berms also act as soft walls creating an inner room for visitors as they first begin the walk. As visitors travel outside the first cell, open views and vistas fill the horizon. The circulation pattern utilizes the berm for about 200 feet but the path surface harshly transitions to concrete and then back to wood. It seems that concrete is difficult to keep clean and unstained, and t stands out as being overbearing in such a natural environment. The pavement could be changed to something softer.

Table 11.6 – Wackodahatchee Wetlands Information Sheet

Location	13026 Jog Road, Delray Beach, Florida
Acreage	50 acres
Built	About 1996
Design Team	Wetland Solutions, Inc.
Waste Treatment Capacity	2 MGD
Type of Waste at Inflow	Secondarily treated wastewater
Hydrology	Recirculated infiltration, to prevent deep injection well disposal
Discharge	Overflow to local canal
Management	Palm Beach Water Utilities
List of Amenities	Three gazebos, extensive boardwalk, benches, multiple kiosks
Estimated Number of Annual Visitors	160,000
Educational Programs	Monthly tours
Human Use Per Acre	3,200

General recommendations include utilizing more berms as circulation routes and increasing the circulation route to include more of the wetland. Because no major recommendations were made, a conceptual proposed plan was not included. Of all the projects reviewed, this project was both the most successful in attracting visitors and exhibited excellent aesthetic design decision in creating spaces, views, and circulation.

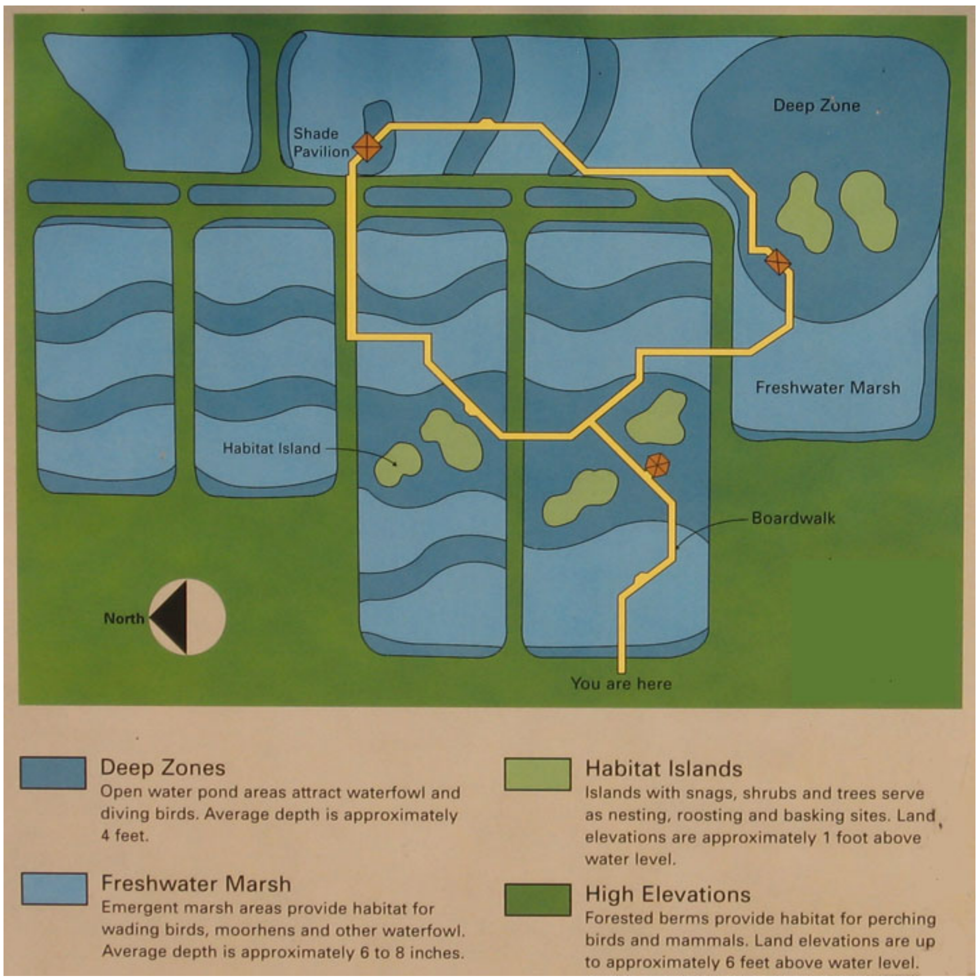

Figure 11.32 – Existing Map of the Wakodahatchee Wetland

(Photo by Author of Park Signage)

The Wakodahatchee Wetlands have succeeded in multiple ways by integrating an efficient wetland, diverse ecology, and an extremely popular wetland to visit. The only real problems for this wetland have stemmed from not planning for enough human use. Since the original lot of 12 parking stalls didn't accommodate the traffic, an additional 28 stalls were added, but parking still fills up at times.

<u>Green Cay Nature Center</u>

Figure 11.33 – View of the Nature Center Framed by an Vegetated Island (Photo by Author).

Green Cay Nature Center was a project built on the successes of the Wakodahatchee Wetland. Both Green Cay Nature Center and Wakodahatchee Wetland serve the same wastewater facility and are only about one mile away from each other. Both of the projects are extremely near Lake Okeechobee and part of the Everglade system.

The land for the nature center was formerly used as a bell pepper farm. Throughout 40 years of farming, the owners, Ted and Trudy Winsberg, had watched many surrounding farms being developed as residential subdivisions. Because of the Winsberg's commitment to the environment, they offered the farm to Palm Beach County at a substantially lower price. The county was able to raise a bond to buy the farm and create the wetlands and nature center.

Figure 11.34 – View from Gazebo to Nature Center (Photo by Author).

Shade is widely abundant amidst the multiple built structures on site. Tree foliage also adds shade along with visual interest and increases the path's sense of adventure.

Figure 11.35 – Classroom Within the Nature Center Overlooking the Wetland

(Photo by Author)

Figure 11.36 – Existing Map of Green Cay Nature Center (Pamphlet at Nature Center, Artist Unknown).

Green Cay Nature Wetland was community funded and is community supported. The nature center was designed to be the central viewpoint. Upon viewing the wetland from the nature center after entering the site, there is little vegetation and views abound. The natural tendency and design intent is for visitors to get out and explore the wetland.

Table 11.7 – Green Cay Nature Center Fact Sheet

Location	12800 Hagen Ranch Road, Boynton Beach, Florida 33437
Acreage	100 acres of wetland, 170 acre parcel
Built	2005
Design Team	Landscape architect: Mike Rawls (Palm Beach Water Utilities Engineer: Hazen & Sawyer Environmental Scientist: Restoration Partners, Inc.
Waste Treatment Capacity	5 MGD
Type of Waste at Inflow	Secondarily treated wastewater
Hydrology	Recirculated infiltration
Discharge	Overflow to local canal
Management	Palm Beach Water Utilities, Palm Beach County's Park and Recreation Department
List of Amenities	1.5 miles of elevated boardwalk, multiple interpretive signs, large nature center
Estimated Number of Annual Visitors	240,000
Educational Programs	Multiple- 4,200 K-12 children in 06'-07' school year
Human Use Per Acre	2,400

The county was extremely concerned about safety in the design and planning of the facility and boardwalks. To eliminate any possibility for human contact with the water extremely sturdy boardwalks and railings were installed along all circulation routes within the wetland. Boardwalks were installed on the large islands as well. The plan was created by eight design professionals headed by the Palm Beach County landscape architect Mike Rawls. He functioned as the project manager, managing, coordinating, performing field work and designing the entry and parking lot. An early concept of the wetland was initiated by Jim Bays from CH2MHILL.

Although the site was designed extremely well, recommendations include introducing a recreation area and utilizing berms more efficiently. A small picnic or green area for visitors would help change the sense of the center into a community asset and park. Also, although boardwalks are appreciated, they only need to be used to access areas that a berm won't reach. A blend of both boardwalks and natural trails on top of berms can add to the economy and interest of the user experience.

Conclusion

After visiting different treatment wetland sites, a simple design protocol was applied or analyzed. The success of the design protocol to identifying failures and successes within existing treatment wetlands shows that circulation and space creation is essential for effective visual aesthetics. Since the protocol is only conceptual, significantly more design thought process must go into the actual design of treatment wetlands. Similar deficiencies in many projects surfaced including a lack of mystery and few shaded areas. Designs that successfully incorporated human use never occurred by chance. Three categories of treatment wetlands seemed to emerge:

1. *Well designed*; sites that were well designed for incorporating human use by an interdisciplinary design team and setup an integrated management organization (Green Cay and Wakodahatchee Wetlands).

2. *Moderately designed*; sites that had significant design process and are fairly successful at attracting visitors to the wetland. However, alterations, add-ons, and other design afterthoughts are evident. Flyers, maps and questionnaires are prevalent but the tone of the building and receptionist is somber and businesslike rather than the sense you may get at welcome center (Phinizy Nature Swamp, Orlando Easterly Wetlands, and Viera Wetlands).
3. *Poorly designed*; sites that have very little design forethought for human use. Signage is often worn, lost, or misplaced. Information may be incomplete or lacking completely. The worker or receptionist is not trained in handling or directing the public (Carolina Bay Wetland, Indian River Wetland).

The management of these projects was pivotal in generating a positive public image. Wastewater facilities cannot expect to exhibit a “wetland visitors welcome” placard, open up their gates to the public, and create an instant relationship with the public. Wastewater treatment facilities in essence become quasi parks and are expected by the public to have the resources to handle the “wetland park’s” visitors. Often a forced union between utility receptionists or the offhand office employee and public park visitor evolves but can be improved with an informed and enthusiastic receptionist or employee. When the challenges of management have successfully been resolved, it is because planning started much earlier than when they realized the wastewater operations manager didn’t have the time or training to handle the public. For large treatment wetlands, a design process beginning with internal management planning to integrate the wastewater treatment department with the parks and recreation (or affiliated) department is essential.

CHAPTER 10

CONCLUSION

> *"A great opportunity now exists to reshape and positively advance the field of treatment wetlands through the field of landscape architecture, whose design motivations encompass a more pluralistic view of the natural environment fostered by a close emotional connection to the created result. This represents a conscious shift in focus from "constructed" wetlands to "creating" wetlands. To borrow Charles Dicken's wonderful lines from Pickwick Papers: 'The whole difference between construction and creation is exactly this: that a thing constructed can only be loved after it is constructed; but a thing created is loved before it exists." This serves as a powerful maxim by which to redirect wetland creation as an evolving and maturing discipline."* (France, 2003:*17)*

Current momentum is growing as professionals collectively understand the potential of treatment wetlands for human use. As designers continue to integrate the knowledge and skills to incorporate human use within treatment wetlands, designers will change from only designing to *allow* people to visit the sites to actually *integrating* people within the design.

Momentum is also gaining as more model projects are being designed and built. Mozingo proposes that ecologic landscapes become "iconic." Mozingo stated,

> By becoming iconic, ecological designs can most effectively redefine good landscape form in response to the most pressing concern of this day—more sustainable human existence. The positive aesthetic experience of 'in ground' built projects which encompass new ideas of good landscape form can positively promote change. It can impel support of the radical alteration in environmental priorities that ecological design implies (Mozingo, 1997:46).

Although not alone, the Green Cay Nature Center acts as such an icon in treatment wetland facilities. Due to diligent planning, the municipality's long term commitment to the environment, and community endorsement, the wetland is one of the most attractive and most visited treatment wetlands in the country.

Consequently, which design principles or elements maximize human use within a treatment wetland? The proposed design protocol set up for recommendations creates the framework for incorporating many of the essential aesthetic principles. Assuming that the protocol would maximize human use, the creation of views, nodes, regions, and vertical structures to create complexity and mystery (explorative principles) are most significant. Although understanding (coherence and legibility) a treatment wetland is important, the flat landscape usually tempers the validity of these principles. Aesthetic elements discussed that are not addressed by the protocol include safety, creating restorative environments, design of pathway materials, edges, gateways, signage, and understandable maps.

Surprisingly, altering the form of berms to be curvilinear doesn't seem to have as strong an effect on visual appeal. This is probably because berms all exist on a horizontal plane which only gets accentuated when a vertical element is present on the berm. Also, the visual presence of berms is muted due to sinuous vegetation within the wetland cells.

Furthermore, the design of treatment wetlands provides a unique forum to further understand and integrate interdisciplinary cooperation, especially among engineers, ecologists, and landscape architects. Effective hydraulic efficiency does not necessarily imply effective land use efficiency, as the Indian River Wetlands clearly indicate. Also, synergistic benefits can be seen in sites that take a cooperative and early approach to designing wetlands.

Community involvement may be the most important factor in creating successfully visited wetlands. As communities embrace treatment wetlands, integration of multifunctional parks will become the norm. Robert France said,

> Recently, I attended a conference at which one of the speakers (who was in the process of updating a major guidebook about wetland construction) dodged several questions from the audience concerning the possibility of designing for multiple purposes. Defending himself, this individual stressed that the guidebook he was working on for the EPA was concerned with "blue-collar" wetlands, those for which, because of obvious space limitations (i.e., suburban settings), it was therefore impossible to create functions (presumably aesthetics and wildlife benefits) other than those intended engineering solutions to either waste-or storm-water management. The difference between a utilitarian blue-collar wetland and a multipurpose white-collar wetland has really much less to do about absence of space than it has to do about absence of *imagination* (France, 2002: 296).

Assuming centralized waste collection will continue to be preferred over alternatives, more wastewater treatment facilities will continue to be developed. These plants are often industrial-looking facilities with barbed wire fences and appear as very unfriendly places to the public. Utilities have very little regular interaction with the public except for handling payment of water bills, sometimes dealing with individual land owners over easement issues, and some interaction with planners and designers for new developments. Treatment wetlands designed for community use allows this bridge to be gapped.

Due to population growth, wastewater treatment facilities are often looking at expansion projects. Tighter environmental quality standards require facilities to meet higher rates of water purity. This often leads to the exploration of alternative solutions to traditional plant methods. The treatment wetland solution will continue to be viable as long as technology struggles efficiently remove particular constituents (such as phosphorus).

Municipal treatment wetlands pose several positives such as being economically feasible, sustainable, ecologically sound, community oriented, and attractive multi-use spaces for humans; yet, they continue to be relatively uncommon. Reasons for this scarcity stem from multiple avenues, inflexible regulations, unfunded initiative programs, uninformed or uninterested design teams, and public ignorance or uneasiness. Luckily, these difficulties present manageable challenges since momentum seems to be shifting in favor of treatment wetlands. Regulators continue to have a greater depth of research and built projects on which to base their requirements, regulations and approvals. Although the original innovative initiative program continues to go on unfunded, multiple projects are continuing to go forward with construction of treatment wetlands based on the sole merits of wastewater treatment wetlands. The design of treatment wetlands is a small and growing niche among scientist, engineers, landscape architects, and other designers. As methods and design approaches continue to evolve, there will be greater understanding and interest in multi-disciplinary design approaches. As ecological awareness, conservation ethics, environmental education, and non consumptive wildlife recreation continue to increase, the public will continue to increase their appreciation for and use of treatment wetlands.

BIBLIOGRAPHY

Aesthetics - Definitions from Dictionary.com. (2008). (Lexico Publishing Group, LLC) Retrieved January 15, 2008, from Dictionary.com: http://dictionary.reference.com/search?q=aesthetics

Bastian, R. K., Shnaghan, P. E., & Thompson, B. P. (1989). Use of Wetlands for Municipal Wastewater Treatment and Disposal - Regulatory Issues and EPA Policies. In D. Hammer (Ed.), *Constructed Wetlands for Wastewater Treatment.* Chelsea, MI: Lewis Publishers.

Batzer, D. P., & Sharitz, R. R. (2006). *Ecology of Freshwater and Estuarine Wetlands.* University of California Press.

Benjamin, T. S. (1993). *Alternative Treatment Methods as Community Resources: The Arcata Marsh and Beyond.* Berkeley: University of California at Berkeley.

Broomhall, D., & Kerns, W. R. (1997, November). *The Status of Wetlands Management*. (Virginia Cooperative Extension Publication Number 448-106) Retrieved January 29, 2008, from http://www.ext.vt.edu/pubs/waterquality/448-106/448-106.html

Campbell, C. S., & Ogden, M. H. (1999). *Constructed Wetlands in the Sustainable Landscape.* John Wiley & Sons, Inc.

Carlson, A. (1990). Whose Vision? Whose Meanings? Whose Values? Pluralism and Objectivity in Landscape Analysis. *Vision Culture and Landscape: working papers form the Berkeley symposium on cultural landscape interpretation* . (P. Groth, Ed.) Berkeley, CA: Department of Landscape Architecture, University of California at Berckeley.

CH2M HILL. (1999). *Executive Summary, Treatment Habitat and Wildlife Use Assessment.* Government Document.

Colinvaux, P. A. (1973). *Introduction to Ecology.* Wiley.

Costanza, R., Dd'Arge, R., de Groot, S., Farber, S., Grasso, M., Hannon, B., et al. (1997). The Value of the World's Ecosystem Services and Natual Capital. *Nature , 387* (6230), 253-260.

Dahl, B., & Molnar, D. J. (2003). *Anatomy of a Park: Essentials of Recreation Area Planning and Design.* Waveland Press.

Dahl, T. (1990). *Wetland Loses in the United States, 1780 to 1980*. Retrieved February 1, 2008, from http://www.npwrc.usgs.fov/resource/wetlands/wetloss/summary.htm

Daniels, T. R. (2001). Whither scenic beauty? Visual landscape assessment in the 21st century. *Landscape and Urban Planning , 154* (1-4), 267-281.

Depletion and Conservation of Natural Resources - Wetlands - fragile Ecosystems. (2008). (Net Industries) Retrieved January 11, 2008, from Library Index: http://www.libraryindex.com/pages/1160/Depletion-Conservation-Natural Resources-WETLANDS-FRAGILE-ECOSYSTEMS.html

Development, W.B. (2005). *DuPont Victoria, Community engagement leads to enhanced wetland program.* Retrieved November 12, 2007, from http://www.wbcsd.org/web/publications/case/dupont_victoria_wetland_full_case_web.pdf

(1989). Wetlands: The Lifeblood of Wildlife. In J. Feierabend, & D. Hammer (Ed.), *Constructed Wetlands for Wastewater Treatment.* Chelsea, MI: Lewis Publishers.

Ewel, K. C., & Odum, H. T. (1979). *Cypress Domes: Nature's Tertiary Treatment Filter ("Philadelphia Paper"). Gainesville, FL: Center for Wetlands, University of Florida.*

France, R. L. (2002). *Handbook of Water Sensitive Planning and Design.* Lewis Publishers.

France, R. L. (2003). *Wetland Design, Principles and Practices for Landscape Architects and Land-Use Planners.* W.W. Norton.

Ghermandi, A. (2005). *Evaluating Functions and Benefits of Constructed Wetlands.* Retrieved March 25, 2008, from http://www.feem-web.it/ess/ess05/files/Ghermandi1.pdf.

Gobster, P. H., Nassauer, J. I., Daniel, T. C., & Fry, G. (2007). The shared landscape: what does aesthetics have to do with ecology? *Landscape Ecology , 22*, 959-972.

Gosselink, J. G., & Turner, R. E. (1978). The Role of Hydrology in Freshwater Ecosystems. In R. E. Good, D. F. Whigham, & R. L. Simpson (Eds.), *Freshwater Wetlands.* New York: Academic Press, Inc.

Guntenspergen, G. (1985). *Discussion Regarding Vegetation Dynamics, Buried Seeds and Water Level Fluctuations in Coastal Wetlands*. (H. H. Prince, & F. M. D'Itri, Eds.) Lewis Publishers.

Hammer, D. (Ed.). (1989). *Constructed Wetlands for Wastewater Treatment.* Chelsea, MI: Lewis Publishers.
Experience. *Environment and Behavior , 23* (1), 3-26.

History of the Augusta Phinizy Nature Swamp. (2004, February 2). Retrieved March 7, 2008, from The Augusta Chronicle: http://chronicle.augusta.com/stories/020204/met_218107.shtm

Hough, M. (1984). *City Form and Natural Processes.*

Howard, P. (2003). *Management, Interpretation, Identity.* Continuum International Publishing Group.

Hultsman, J. T., Cottrell, R. L., & Hultsman, W. Z. (1998). *Planning parks for people.* State College, PA: Venture Publishing.

Jiang, F., Beck, M.B., Cummings, R.G., Rowles, K.,& Russell, D. (2005). Estimation of Costs of Phosphorus Removal in Wastewater Treatment Facilities: Adaptation of Existing Facilities. *Water Policy Working Paper #2005-011*, 1-45.

Kadlec, R. H., & Knight, R. L. (1996). *Treatment Wetlands.* CRC Press, LLC.

Kaplan, R., & Kaplan, S. (1998). *The Experience of Nature.* Cambridge University Press.

Knight, R. L., & Gutzwiller, K. J. (1995). *Wildlife and Recreationist, Coexistence through Management and Research.* Island Press.

Knight, R. (2007, March 13). Personal Interview. (R. Bentley, Interviewer)

Lightbody, A. F., Nepf, H. M., & Bays, J. S. (2007). Mixing in Deep Zones within Constructed Treatment Wetlands. *Ecological Engineering , 29*, 209-220.

Lyle, J. T. (1996). *Regenerative Design for Sustainable Development.* John Wiley and Sons.

Lyons, E. (1983). Demographic Correlates of Landscape Preference. *Environment and Behavior , 15* (4), 487-511.

Marble, A. D. (1992). Aquatic Diversity/Abundance. In A. D. Marble, *A Guide to Wetland Functional Design* (pp. 133-162). Lewis Publishers.

Marble, A. D. (1992). Wetland Dependent Bird Habitat Diversity. In A. D. Marble, *A Guide to Wetland Functional Design* (pp. 163-202). Lewis Publishers.

McCutcheon, S. C., & Schnoor, J. L. (2003). *Phytoremediation: transformation and control of contaminants.* Hoboken, N.J.: Wiley-Interscience.

McHarg, I. (1969). *Design with Nature.* Garden City, NY.

Mozingo, L. A. (1997). The Aesthetics of Ecological Design: Seeing Science as Culture. *Landscape Journal , 16* (1), 46-59.

Nassauer, J. I. (1995). Messy Ecosystems, Orderly Frames. *Landscape Journal , 14*, 161-170.

Nassauer, J. I. (2004). Monitoring the Success of Metropolitan Wetland Restorations: Cultural Sustainability and Ecological Function. *Wetlands , 24* (4), 756-765.

Nassauer, J. I. (1997). *Placing Nature, Cultural and Landscape Ecology.* Island Press.

Nicols, D. S. (1983). Capacity of New Wetlands to Remove Nutrients from Wastewater. *Journal of Water Pollution Control , 55*, 495.

Persson, J., Somes, N., & Wong, T. (1999). Hydraulics Efficiency of Constructed Wetlands and Ponds. *Water Science and Technology , 40* (3), 291-300.

Orr, David (1992) *Ecological Literacy.* Albany: State University of New York-Albany, p 24.

Physical Alterations and Destruction of Habitats (PADH). (2008, March 2). Retrieved March 16, 2008, from Global Programme of Action for the Protection of the Marine Environment from Land-based Activities:http://padh.gpa.enep.org

Reed, D. J., & Perdue, R. R. (1979). *Park Planning and Design: An Evaluation Approach.* National Recreation and Park Association.

Rosenberg, E. (1996). Public Works and Public Space: Rethinking the Urban Park. *Journal of Architectural Education* , 89-103.

Ruiz, A., Davis, A.K., Fish, A., & Maerz, J.C. (2007). *Hypercalcemic Abnormalities of Tadpoles Found in Wastewater Treatment Wetlands*. Chattanooga, TH: SEPARC Conference.

Sather, J. H. (1989). Ancillary Benefits of Wetlands Constructed Primarily for Wastewater Treatment. In D. Hammer (Ed.), *Constructed Wetlands for Wastewater Treatment.* Chelsea, MI: Lewis Publishers.

Schuyt, K., & Brander, L. (2004) Living waters. The economic values of the world's wetlands. *WWF publication prepared with support from the Swiss Agency for the Environment, Forests and Landscape*. Amsterdam

Sees, M. (2006, January 4). *The Orlando Easterly Wetlands*. Retrieved January 23, 2008, from Florida - Department of Environmental Protection: www.dep.state.fl.us/geology/programs/hydrogeology/hydro_wkshp/discussion_sessions/sees.pdf

Sewage Disposal. (2007). Retrieved January 20, 2008, from MSN Encarta: http://encarta.msn.com/encyclopedia_761565852/Sewage_Disposal.html

Smardon, R. C. (1989). Human Perception of Utilization of Wetland for Waste Assimilation or How Do You Make a Silk Purse Out of a Sow's Ear? In D. Hammer (Ed.), *Constructed Wetlands for Wastewater Treatment.* Chelsea: Lewis Publishers.

Spirn, A. W. (1984). *The Granite Garden: Urban Nature and Human Design.* New York: Basic Books.

Stowe, H. B. (1856). *Dred: A Tale of the Great Dismal Swamp.* Boston: Philips, Sampson and Company.

Surrency, D., & Owsley, C. M. (2003). *Wetland Plants Selected for Constructed Wetlands and Stormwater Systems.* Retrieved February 2, 2008, from USDA Natural Resources Conservation Services: http://www.northinlet.sc.edu/training_pages/constructed_wetlands/tools_pages_docs/Recommendedaquatic.pdf

Syme, G. J., Fenton, D. M., & Coakes, S. (2001). Lot Size, Garden Satisfaction, and Local Park and Wetland Visitation. *Landscape and Urban Planning , 56*, 161-170.
Tennessen, C. M., & Cimprich, B. E. (1995). Views to Nature: Effects of Attention. *Journal of Environmental Psycology , 15* (1), 77-85.

Thayer, R. (1994). *Gray World, Green Heart, Technology, Nature and teh Sustainable Landscape.* New York: John Wiley and Sons, Inc.

The Interstate Technology & Regulatory Council Wetlands Team. (2003, December). *Technical and Regulatory Guidance for Constructed Treatment Wetlands.* Retrieved September 27, 2007, from Interstate Technology & Regulatory Council: http://www.itrcweb.org/Documents/WTLND-1.pdf

The Ramsar Bureau. (1999). *Wetlands - An Inspiration in Art, Literature, Music, and Folklore.* Retrieved November 17, 2007, from Ramsar Convention on Wetlands: http://www.ramsar.org/info/cultural_heritage_e10.pdf

Thompson, J. W., & Sorvig, K. (2000). *Sustainable Landscape Construction, A Guide to Green Building Outdoors.* Island Press.

Thoreau, H. D. (1962). *The Journal of Henry D. Thoreau* (Vol. 2). (B. Torrey, & F. H. Allen, Eds.) Courier Dover Publications.

Turner, R., Redmond, A. M., & Zedler, J. B. (2001). Count it by Acer or Function: Mitigation Adds Up to Net Loss of Wetlands. *National Wetlands Newsletter* .

United States Environmental Protection Agency. (2000, September). *Manual - Constructed Wetlands Treatment of Municipal Wastewaters.* Retrieved December 5, 2007, from www.epa.gov/ORG/NRMRL

Values of Urban Trees. (n.d.). Retrieved January 5, 2008, from A Technical Guide to Urban and Community Forestry:http://na.fs.fed.us.spfo/pubs/uf/techguide/values.htm

Viñales, M. J. (2001, October 16). *Wetlands as historical and ethnological archies.* Retrieved October 5, 2007, from The Ramsar Convention on Wetlands: http://www.ramsar.org/mtg/mtg_reg_europe2001_6vinals_e.doc

Visual Resources/Aesthetics. (2004, August 23). Retrieved February 15, 2008, from Environmental Setting, Impacts and Mitigation – Proposed Project: http://ci.pittsburg.ca.us/pittsburg/pdf/tbc/4-13-Visual.htm

Wal-Mart - Sustainability Progress Report. (2007, November 15). Retrieved January 29, 2008, from Wal-Mart Stores: http://walmartstores.com/Sustainability/7951.aspx

Wittgren, H. B., & Maehlum, T. (1997). Wastewater treatment wetlands in cold climates. *Water Science and Technology , 9*, 45-53.

Zaitzevsky, C. (1982). *Frederick Law Olmsted and the Boston park system.* Cambridge: Harvard University Press.

APPENDIX

REVIEW OF ARCATA MARSH THESIS

Background

"Alternative Wastewater Treatment Methods as Community Resources: The Arcata Marsh and Beyond" was written by Thomas Benjamin, a graduate landscape architect student at the University of California Berkley, in 1993. The topic of the thesis was a 154-acre marsh in Arcata, California and its effects on the community. The major goal was to measure the level of success or failure of the Arcata Marsh in its role as a community resource. Benjamin conducted a survey aimed at understanding the connection that the community had with the marsh and their underlying values associated with the marsh.

Benjamin's major conclusions of the thesis were that:

1. The Arcata Marsh has been a great success in its role as a community open space, recreational, ecological and educational resource.
2. Integrating uses constitutes "higher and better use" of land set aside for necessary infrastructural function.
3. The community finds pride and unity as they display slogans such as "giving back to the earth" and "flushing with pride."

Other general observations he made were that the public input and support from the inception of the planning process helped, the political struggle added to the communities' enthusiasm and cohesiveness when the project was approved, maintaining public involvement is important in building community pride, there is strength in accommodating the multiple interests of its users, hunting was a planning problem, and better signage would help locate the site from town.

History

The history of the marsh was actually very telling of the communities support behind the park. The site was first used as wastewater treatment through the creation of oxidation ponds originally built on the site in 1947 with chlorination contact tanks added in 1966 and a dechlorination facility constructed in 1975. In 1975 the Water Resources Control board of California required all estuarine wastewater discharges be phased out at the earliest practical date. A fifty million gallon per day wastewater treatment plant was planned in nearby Eureka, but the proposed pipelines in the landscape scared the local community. A new plan formed from professional engineers, fisheries specialists, and public works officials to implement treatment wetlands. In the late 1970's the concept of treatment wetlands was very new and viewed as extremely risky. In 1977 Arcata presented the alternative plan to the Regional Water Quality Control Board and it was rejected for lack of scientific research. In 1979 the state funded a $400,000 grant for a pilot study. The pilot study was implemented from 1979 to 1983 and showed that it could meet national pollutant discharge elimination system standards. As the community officials continued to push the idea through the state and local approvals, the community vigorously supported and encouraged the idea. The battle was eventually won in 1983 and continued use and expansion continued from that time on. The marshes were expanded in 1986. After winning a grant of $100,000 from the Harvard Innovations in Government award in 1987, Arcata opened an interpretive center in May 1993 with the help of an additional $56,000 in local funds. There is an adjacent land-fill that has been planted as well. In addition to the interpretive center, the current park includes multiple paths, signage, education programs, picnic areas, an aquaculture pond, and a wildlife refuge. The largest portion of the land use is passive in character, including walking, bird watching, picnicking and educational-related activities.

Survey

The survey was a study of perceptions, values and preferences as related to community impacts. Benjamin surveyed face-to-face on-site and off-site at various locations within the city. There were twenty-three questions with an open question taped for the conclusion. Eighty people were surveyed- half on-site and half off-site.

The survey covered the following categories: general background, use-related, understanding and awareness, perceptions and feelings toward marsh, perceptions of community impacts, and perceptions of the value of the marsh.

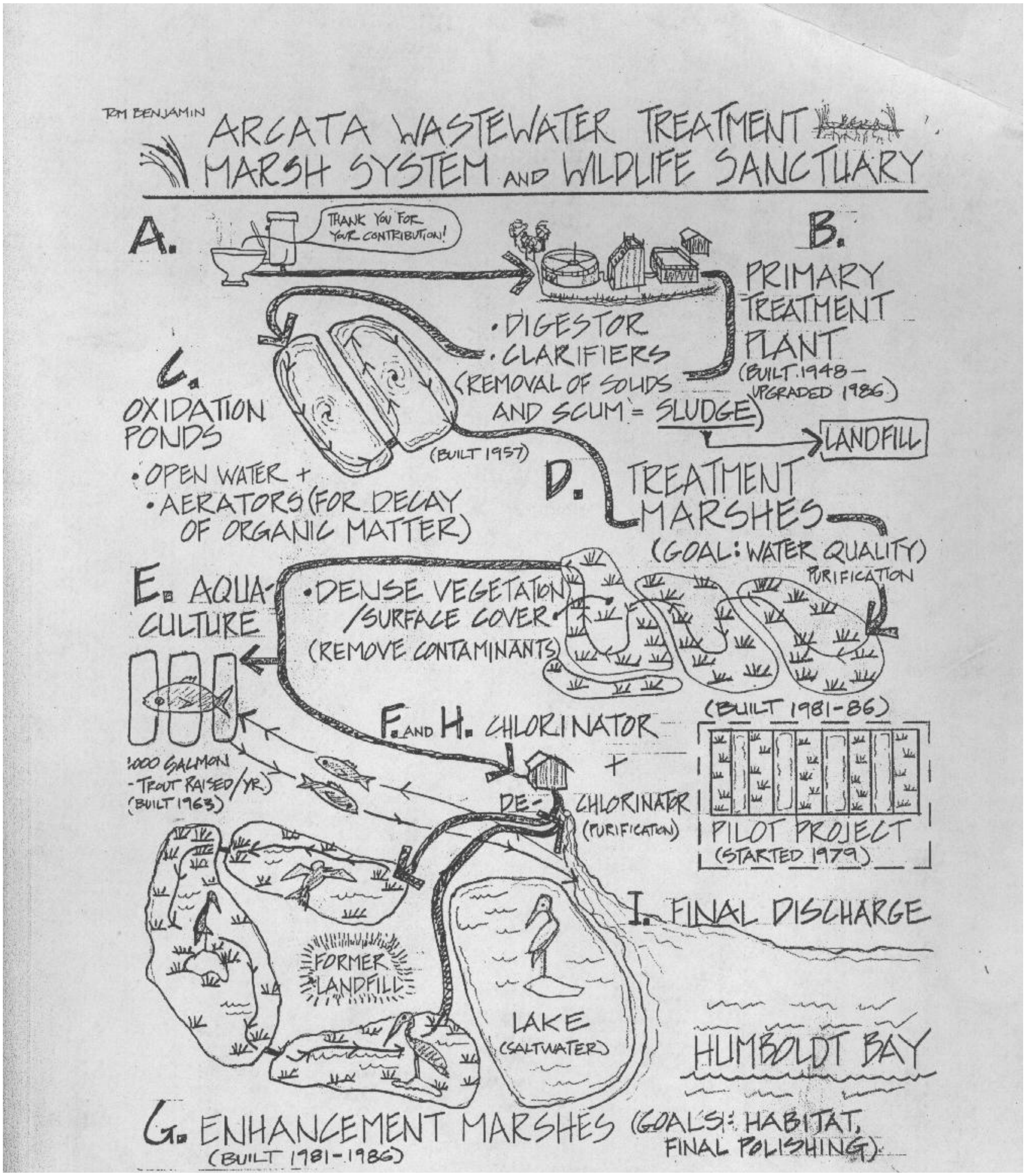

Figure A.1 – Diagram of the Element and Features of the Arcata Wastewater Treatment Marsh and Wildlife Sanctuary (Benjamin, 1993)

General Background

The participants in the survey were consistent with the population makeup of Arcata. Fifty-four percent of the respondents identified the Arcata Marsh as their favorite open space. When asked to draw a map of Arcata, the two most prominently drawn landmarks were the marsh and Arcata's downtown square. Forty-six percent of respondents said that the Marsh was easy to find. Since the survey was focused on the marsh, the participant's answers were often skewed in favor of the marsh.

Use-Related Questions

Respondents were asked how often they visited the site. Twenty-five percent of respondents were non-users of the marsh, 60% visited the marsh on an occasional basis, and 23% at least twice per week. Sixty-six percent of respondents who had visited showed a strong desire to revisit the site. When people had visited, forty-nine of the came by car, twenty-one persons walked, eleven had biked, and four had jogged or rollerbladed. The three most popular activities according to the responses were walking (60%), bird watching (60%), and looking at the scenery or relaxing (58%). Other responses included learning or education (27%), picnicking (22%), biking (20%), touring (18%), fishing (8%), and hunting (5%). Despite the adjacent landfill and wastewater, many people still found picnicking palatable. Forty-six percent of the respondents reported staying from one to two hours. Thirty-five percent reported staying for less than one hour and 18% for over two hours. Thirty-nine percent of respondents preferred solitary visits and 48% preferred company. If visitors came with someone, 38% came with family members, 37% with family, friends or significant others, and 25%

visited with friends only. Benjamin surmised that the marsh offers a solitary getaway or an accessible escape and thus a large percentage of visitors preferred to come alone.

Understanding and Awareness

Only 44% of all respondents said they were familiar or very familiar with the Marsh while 32% said they were unfamiliar with the site. Seventy percent of respondents knew that the marsh had more functions than just recreation or open space. Forty-four percent of respondents defined the other functions as wastewater treatment and 33% defined wildlife habitat as another function. Education and experimentation were also listed but had a 5% or lower response. Forty-one percent of respondents were aware of the uniqueness of the site compared to other marshes. And 43% of respondents knew what was on the site before the wetlands were created.

Two locally sponsored festivals focused on the Arcata waterfront (organized by Friends of the Arcata Marsh and the Arcata Department of Public Works) are the Flush with Pride Festival and The Waterfront Days Festival. The Waterfront Days Festival was discontinued in 1992 due to budget constraints. Fifty-five percent of respondents hadn’t heard about the festivals and only 33% had heard or attended the two festivals.

Perceptions and Feelings Toward Marsh

When respondents were asked about their interest level in the marsh, 65% answered as high interest, 10% as moderate, and 25% were non-responses. When asked why the marsh was interesting, most respondents said “birds and wildlife.” Four respondents listed peacefulness, three said it was an interesting place to walk, three others identified aesthetic qualities such as viewing sunsets, the weather, and the tides and two identified educational interest.

One-third of the answers to what they liked about the marsh were the birds and wildlife and another third of the answers were the aesthetic qualities. One respondent insightfully wrote, “The open, horizontal quality of the marsh with its spectacular 360-degree view of adjacent Humbolt Bay, the coastal mountains to the East, and the town itself, is rare for an area which is densely vegetated by dark redwoods.” Other answers to what they liked were the peacefulness or calming qualities with 23% of responses. Peace, quiet, solitude, serenity and relaxed were frequent words used to describe the site. Another ten percent of the responses included wastewater treatment and eight percent mentioned access to bay. Ironically, some said the site’s “untouched” character and “absence of man-made things.” Others said the fact that the site is well-maintained, managed and directional maps provided.

Respondent’s answers to what they disliked about the marsh included odor from seven respondents. Other answers included trash in the parking lot, dog waste, mosquitoes, and people hanging out in cars. Some felt that the site was too small. One respondent said that the five miles of trails should be better maintained. Two female respondents felt negatively about the marsh’s safety and relative seclusion.

Respondents were asked how they would improve the marsh. Eight respondents said nothing, six said parking lot needed cleaning up, one said that dogs and hunters need regulating, another said improved maintenance and another said that the facility needed to be expanded or enlarged. Other answers also included: trails need more maintenance with redwood bark chips, there needs to be more education opportunities and guided tours, more seating and landscaping needed, a stronger connection with onsite stream should be included, a stronger connection with town could be made, more fishing opportunities should be offered, and crime should be stopped everywhere.

The respondents were also asked what would make the site a better place. The following answers were given: enlarge the facility, better trail maintenance, more recreational development, more greenery, better direct access to ponds, more wildlife, less access and more habitat, increase public awareness, less odor, less homeless people, less trash and dog waste.

When asked if the site is better or worse than before the created marsh half said better, one said worse, three said unsure, and the rest were no response possibly because they didn't know the history of the site. When asked why they answered positively or negatively, 26% of respondents answered that integrated wastewater treatment with other uses and creative designing or managed use of site establishes a positive purpose. Sixteen percent mentioned aesthetics, scenery or beauty as major improvements. Thirteen percent believed that the marsh creation resulted in cleanup of site, ten percent said that it created better access to bay, and three percent said that as a park it serves a more diverse set of interests.

Perceptions of Community Impacts

When asked if the impact of the marsh on the community was negative or positive on a scale of one-to-ten(one being the most positive), 55 out of 71 respondents said one or two. Six respondents said three or four and five respondents were not sure of the effects. One respondent felt that it had somewhat negatively affected Arcata. The respondents were also asked how the city of Arcata had been affected by the marsh. The following answers were given (in order of most responses):

1. Wide recognition given to Arcata because the Marsh is a “model” for other communities for improved wastewater treatment.
2. Tourism or revenue.
3. Increased open space and recreational opportunities.
4. Improved environment (better wetland protection).
5. Increased environmental awareness and education.
6. Improved people’s perception of the wastewater treatment process.

Perceptions of the Value of the Marsh

Ninety-three percent of respondents answered that they would support using public money to fund projects such as the marsh, while five percent said they would oppose it and one respondent was undecided. When asked why they would support using public money the respondents gave the following reasons: environmental grounds (conservation, ecological values, habitat), the project provides a better method of wastewater treatment, it provided more valuable space, the project is a good idea, and it offers universal benefits. When asked how the marsh affected the community, the following phrases were the most used: “great resource,” “city asset,” “valuable to community,” and “great for kids/family.”

The respondents gave the following answers (grouped in topics) to the value or lack of values associated with the marsh:

1. Peacefulness/Serenity/Relaxation— “leave worries behind”, immediate meditative release”, “lifts spirits”, “respite”, and “great sense of well-being.”
2. Wildlife/Birding, Land Use/Multiple Use, Educational/Awareness— “tremendous educational value” and wastewater treatment, “it works.”
3. Outside Recognition/Model, Economic Value, Visit, General Feelings— “good place” “nice place to visit and look around.”
4. Aesthetics/Scenery/Beauty
5. Environmental/Ecological
6. Specific Recreational Activities
7. Proximity/Nearness
8. Community Pride— “community enhancement”, “community bonus” “asset for a small area”
9. Tourism
10. History
11. Solitude
12. Universality