Water Resources Assessment of Warner Park Lagoon with Preliminary Management Alternatives

Prepared by

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Underwater Habitat Investigations LLC

For

Warner Park Lagoon Partners:

Wisconsin DNR, Yahara Fishing Club and Wild Warner

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Introduction and Methods

Warner Park Lagoon is a hydrologically modified wetland in the form of a 28 acre pond that surrounds an island. The lagoon is habitat for many bird species, fish populations and numerous other types of wildlife. The pond drains an urban watershed and long term water quality degradation reflects a combination of stormwater runoff, sedimentation and hydrologic changes. Fish kills have occurred in the past due to winterkill (low dissolved oxygen levels) while common carp have posed another long term ecological disturbance.

The Warner Park Lagoon partners, including Wisconsin Department of Natural Resources (WDNR), Wild Warner and Yahara Fish Club (YFC), hired Underwater Habitat Investigations LLC (UHI) to conduct a late summer abridged lagoon survey, review existing data and literature, and suggest management alternatives to improve and protect the pond. YFC provided funding ($2,200) for this project. UHI has conducted numerous surveys and prepared management plans for shallow water lakes, sloughs and ponds in southern Wisconsin.

The lagoon was sampled on September 16, 2014. The survey consisted of water quality profiles measurements at four locations, habitat and wildlife observations and a nearshore fish electroshocking survey (Figure 1). Equipment used included a Yellow Springs Instrument (YSI) model 52 dissolved oxygen (D. O.) - temperature meter, a YSI model 63 pH - specific conductance meter, standard secchi disc, Hach model 2100P Turbidimeter, and a towed DC electroshocker. Water quality samples were submitted to the State Lab of Hygiene for chlorophyll-a (Chl-a), total phosphorus (TP) and total kjeldahl nitrogen (TKN). Chl-a, TP and secchi data were transformed to Trophic State Index (TSI) in Wisconsin Lake Modeling Suite (WILMS). The lagoon outlet was inspected on September 17, 2014 with a Swoffer model 2100 velocity meter to assess water movement between the lagoon and Lake Mendota. On October 2nd, the lagoon was tested again for chloride (Cl) using a YSI Pro Plus meter.

Findings

Disclaimer: This project does not represent a diagnostic and feasibility or engineering design study that would be necessary before a restoration begins. Rather, this significantly abridged survey and analysis was performed after a more detailed study was not funded. This effort represents a first step in the discussions toward developing a comprehensive restoration plan with only a brief description of potential strategies that could be evaluated in more detail based on effectiveness and funding.

Overview: The lagoon was turbid in September but was not degraded as several other shallow lakes and ponds in Dane County this year. However, a limitation was that the results did not represent warm season condition when Cyanobacteria (bluegreen algae) blooms occur more frequently. The weather during the survey was unseasonably cool and dissolved oxygen levels were higher than previous surveys demonstrated. Lagoon water temperatures ranged from 14.3 to 16.5 C (57 – 62 F) during the survey.

D. O. (mg/l): Dissolved oxygen and other chemical profiles were measured at four locations in the lagoon (Figure 1). Figure 2 presents the D. O. concentrations at the four sites, at 0.5 meter intervals. None of the measurements were below the minimum Water Quality Criterion concentration of 5 mg/l established to protect warmwater fish and aquatic life communities. The favorable D. O. concentrations likely reflected cool weather water column mixing, greater saturation potential for colder water and reduced Cyanobacteria blooms. By comparison, bottom water anoxia or very low D. O. was found as part of the 2012 Warner Park Fireworks Study (Bemis 2013) and in 2007 as part of the Dane County ponds aquatic plant management planning project (Marshall et al. 2007). Anoxia at the bottom of the lagoon has significant water quality effects, including increased internal nutrient loading. Winterkills and winterkill conditions favorable for fish kills have also been reported in the past and most recently in February 2009 with a D. O. concentration of only 1.6 mg/l (WDNR files).

Figure 1: Aerial photo of Warner Park Lagoon Sampling Locations

pH (s. u.): pH is a measure of acidity and is the negative logarithm of the hydrogen ion (H^+) concentration. Except for a few pH measurements near the bottom of the lagoon (Figure 3), all measurements reflected neutral to moderately alkaline water that reflect greater amounts of hydroxide (OH^-) and relatively lower H^+. Typical for southern Wisconsin, most pH measurements ranged between 7 and 7.9 s. u. Extreme vertical changes in pH can occur when Cyanobacteria blooms are dense but this was not the case in September 2014. Water samples collected in 2012 (Bemis 2013) revealed higher surface pH (up to 8.3 s. u.) that likely reflected greater Cyanobacteria photosynthesis. Moderate calcium concentrations were recorded in 2012 and were characteristic of alkaline conditions in southern Wisconsin.

Specific conductance (*u*ohms/cm): The specific conductance of the water is a measure of electrical conductance and reflects relative amounts of dissolved cations (+) and anions (-), etc. The specific conductance levels in Warner Lagoon were moderately low in September 2014. The conductivity measurements suggested that surface runoff is the primary water source for the lagoon with minimal groundwater sources. Specific conductance of southern Wisconsin groundwater often exceeds 500 *u*ohms/cm. Anions such as chlorides will increase specific conductance levels but the winter source of chloride (and related conductivity) was likely flushed from the lagoon after the heavy 2014 spring and summer storms. Slightly higher specific conductance levels were recorded in the south bay near the outlet to Lake Mendota (sites 2 and 3) and likely reflected an estuary effect with the lake, that typically sustains specific conductance levels > 400 *u*ohms/cm. Much higher specific conductance levels were recorded in the lagoon during the drought of 2012 (Beming 2013). During this period, less runoff (reduced softwater inputs) and less flushing/dilution of road salt (chloride) likely occurred. High Cl concentrations, exceeding 100 mg/l, were measured twice in the lagoon in July 2012 (Bemis 2013). Cl was only 13.5 mg/l on October 2nd and indicated greater lagoon flushing compared with 2012 sample results. Below average precipitation was recorded for Dane County in 2011-12 while above average rainfall occurred in 2013-14 (NOAA database).

Chl-a (*u*g/l), TP (mg/l), nitrogen (mg/l): Chl-a and TP concentrations in the lagoon indicated seasonally eutrophic conditions at 44.9 ug/l and 0.181 mg/l respectively. The TKN and NO2 = NO3-N concentrations in September were 1.66 mg/l and no detection respectively. The total nitrogen concentration was therefore represented by TKN or total nitrogen to phosphorus ratio of about 9:1. This low N:P ratio indicates nitrogen limitation in the lagoon that favors Cyanobacteria blooms. Numerous surface water samples were tested for TP in 2012 and revealed highly eutrophic to hypereutrophic conditions (Figure 5). Hypereutrophic conditions often coincide with dense Cyanobacteria blooms and are represented by TSI values of $\geq$70. The high phosphorus concentrations measured at that time likely reflected internal loading when water at the bottom of the lagoon became anoxic. Concentrations of both phosphorus and nitrogen in the lagoon sediments are high and can be mobilized into the water column when the overlying water becomes anoxic. Bemis (2013) reported sediment phosphorus concentrations ranging from 1,170 to 1,320 mg/kg (parts per million) and nitrogen from 8,360 to 18,500 mg/kg.

Water transparency: Figure 6 displays the September 16, 2014 secchi transparency measurements and data transformed to TSI, indicating eutrophic conditions. The clearest water was found in the south bay adjacent to Lake Mendota. The September 2014 water clarity was better at Site 1 when compared with a secchi measurement taken at that same location on July

13, 2007 (1.1' or TSI 76 - hypereutrophic) (Marshall et al. 2007). Turbidity samples collected on September 16th were consistent with secchi measurements and reflected low water clarity in the lagoon and slightly lower turbidities were found at Sites 2 and 3 (Figure 7).

Figure 2: Warner Park Lagoon Dissolved Oxygen Profiles September 16, 2014

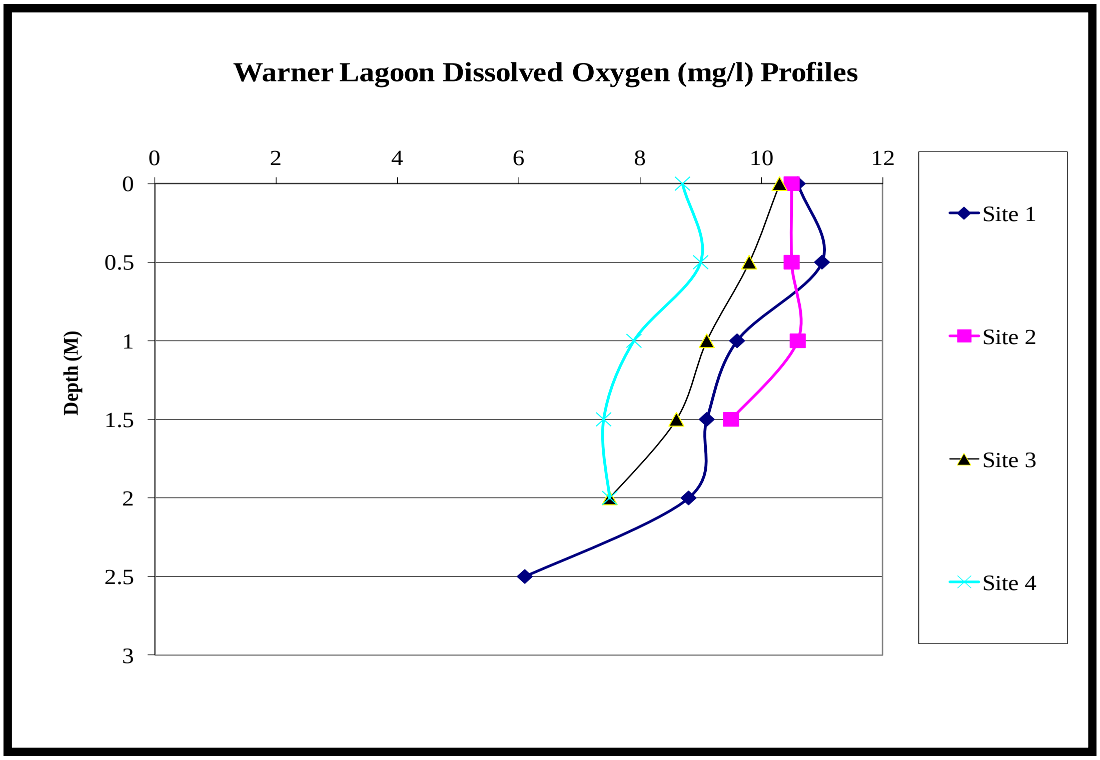


Figure 3: Warner Park Lagoon pH Profiles September 16, 2014

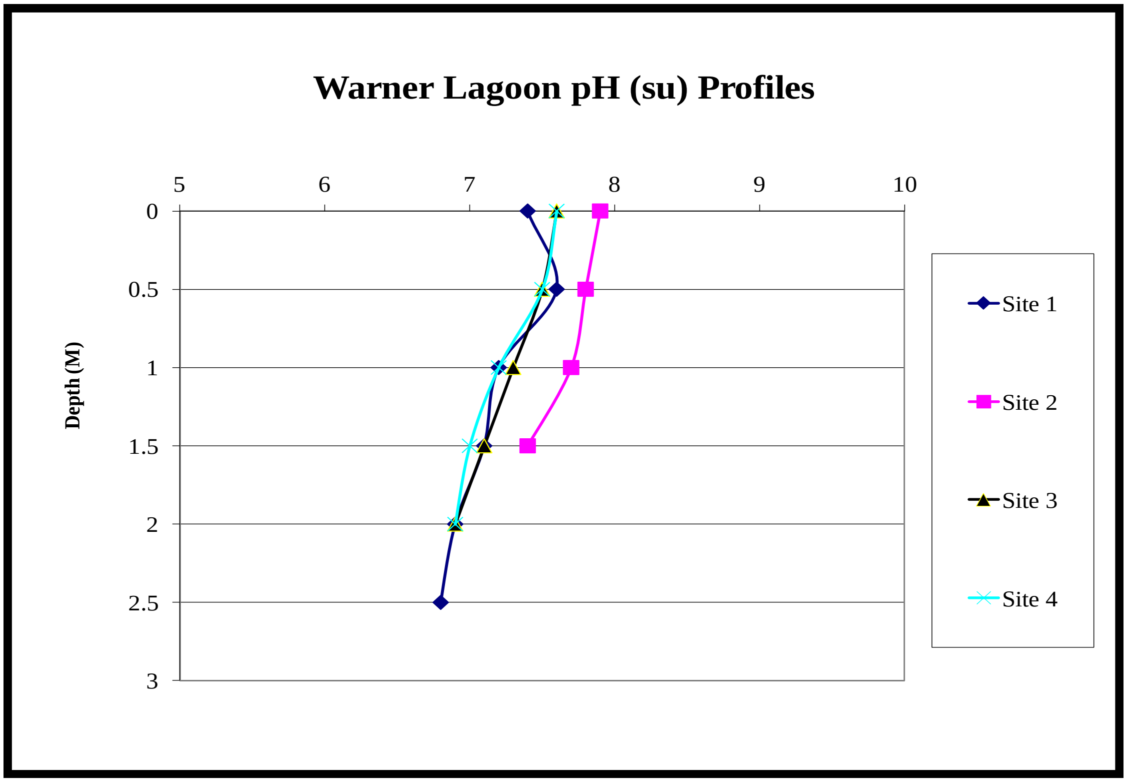


Figure 4: Warner Park Lagoon Specific Conductance Profiles September 16, 2014

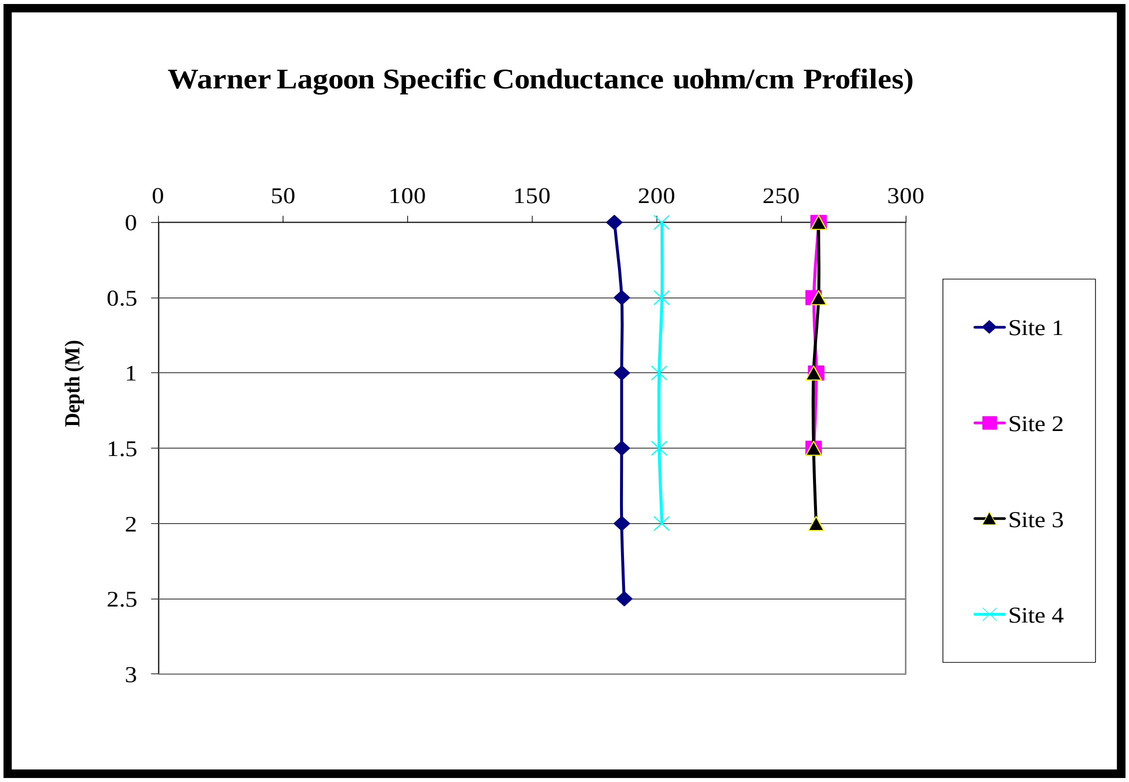


Figure 5: 2012 Warner Park Lagoon TSI Values for TP June – August 2012 and Chl-a and TP September 2014 (> 70 = Hypereutrophic)

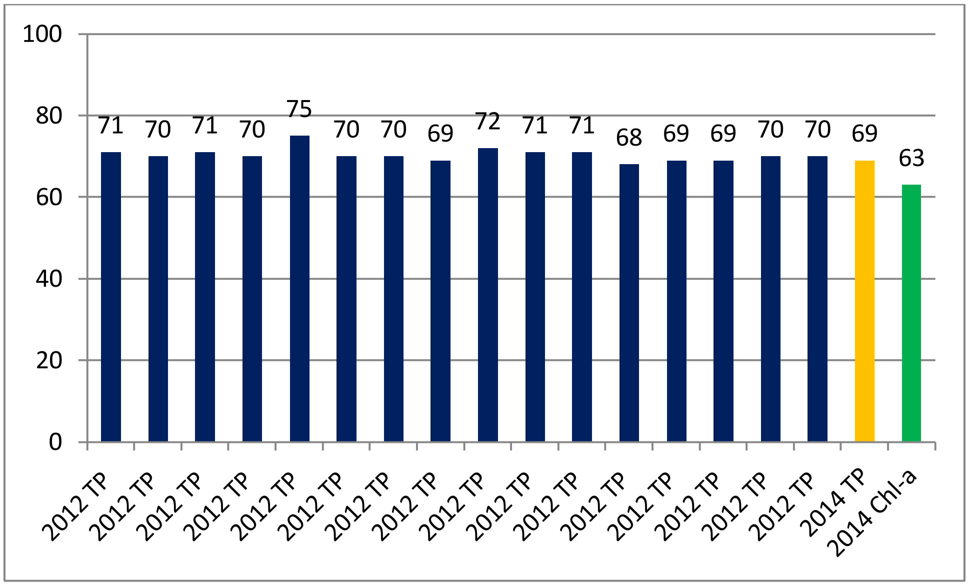
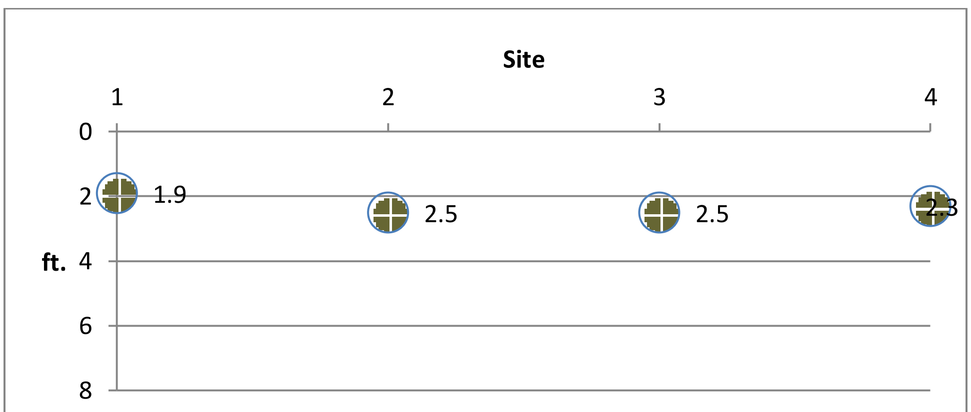


Figure 6: Warner Park Lagoon Secchi Water Clarity Measurements September 16, 2014



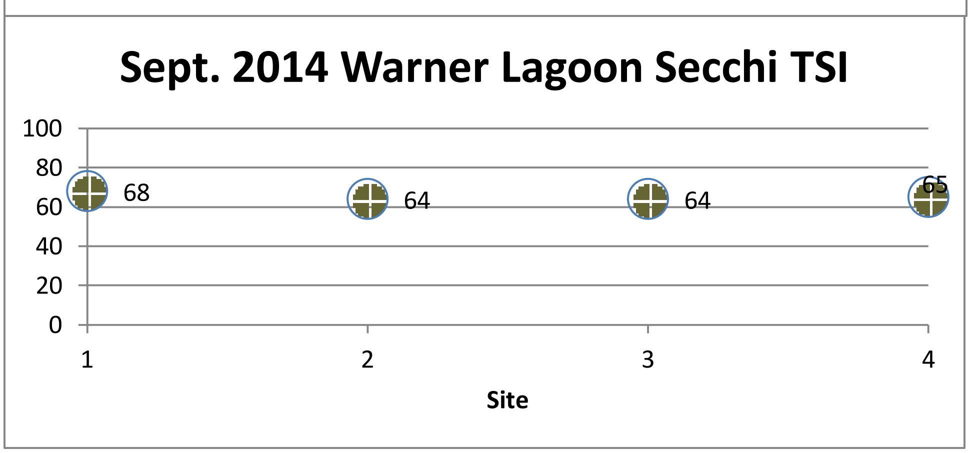
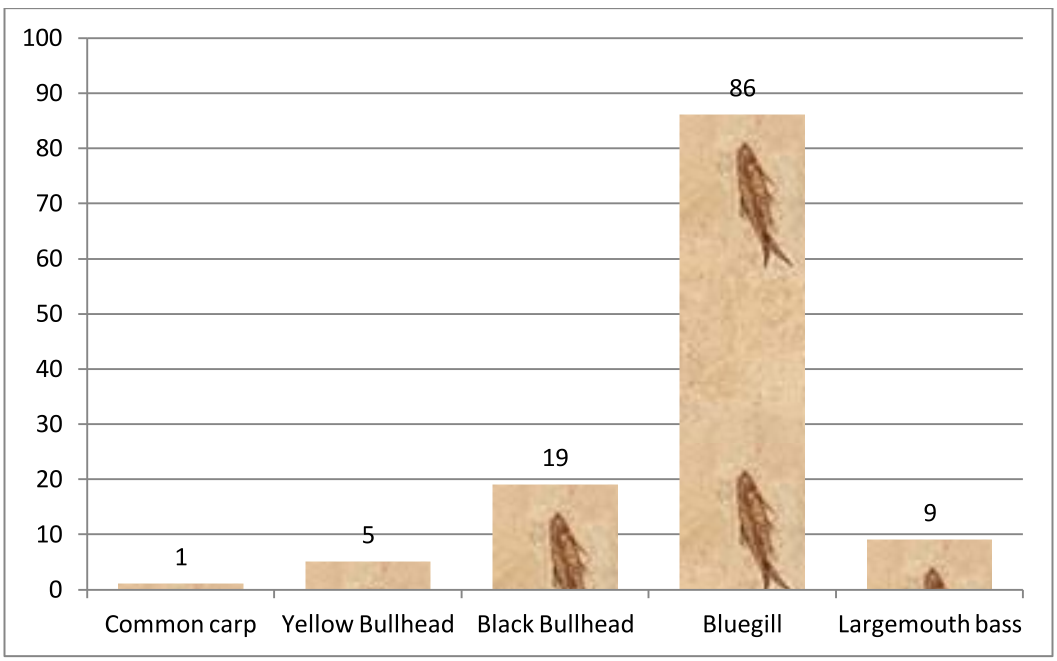


Figure 7: 2014 Warner Park Lagoon Turbidity (NTU) Measurements

Figure 8: September 16, 2014 Warner Park Lagoon Nearshore Fish Electroshocking Results



Nearshore electroshocking survey: Figure 1 identifies the nearshore fish shocking survey area. This effort was not designed to provide population estimates or adult gamefish size data but rather characterize nearshore fish populations that often include juveniles and can indicate recruitment. The DC electroshocker barge was operated at 1.7 amps and 160 volts over a distance of 310 shoreline feet; 21 minutes of shocking. Five species of juvenile fish were collected and indicated bluegill, largemouth bass and bullheads recruitment (Figure 8). A single juvenile common carp was also collected and suggests likely carp reproduction in the lagoon.

Periodic winterkill conditions affect the overall fish community in the lagoon and significant changes can occur from year to year. During a boomshocking survey in 1989, DNR fish biologists recorded 10 species including bowfin, northern pike, golden shiner, buffalo, bullheads, abundant bluegills, black crappie, pumpkinseed, largemouth bass and yellow perch. Eighteen fish species are recorded in the Madison Metropolitan School District "Stewards of the Lakes" report spanning 1983 – 2012.

<u>Wildlife and habitat observations</u>: The shallow water zones of Warner Park Lagoon (< 3') supported areas of dense white water lilies and American lotus. Other submersed aquatic plants recorded on September 16, 2014 included coontail, longleaf pondweed, sago pondweed, leafy pondweed, curly-leaf pondweed (exotic) and Eurasian watermilfoil (exotic). Only two macrophyte species were recorded in 2011, coontail and white water lily, as part of a point intercept survey (Jones 2014). Point intercept surveys often focus on off-shore plant beds and nearshore plants are underestimated. The data indicates that the poor water clarity in the lagoon limits aquatic plant growths to nearshore areas. Dense plant growth in nearshore areas suggests that the current common carp population may not be severe since their aggressive foraging behavior often damages nearshore plants as well. Dense hybrid cattails grow along the south part of the lagoon and elsewhere. Other emergent plants included arrowhead and softstem bulrush.

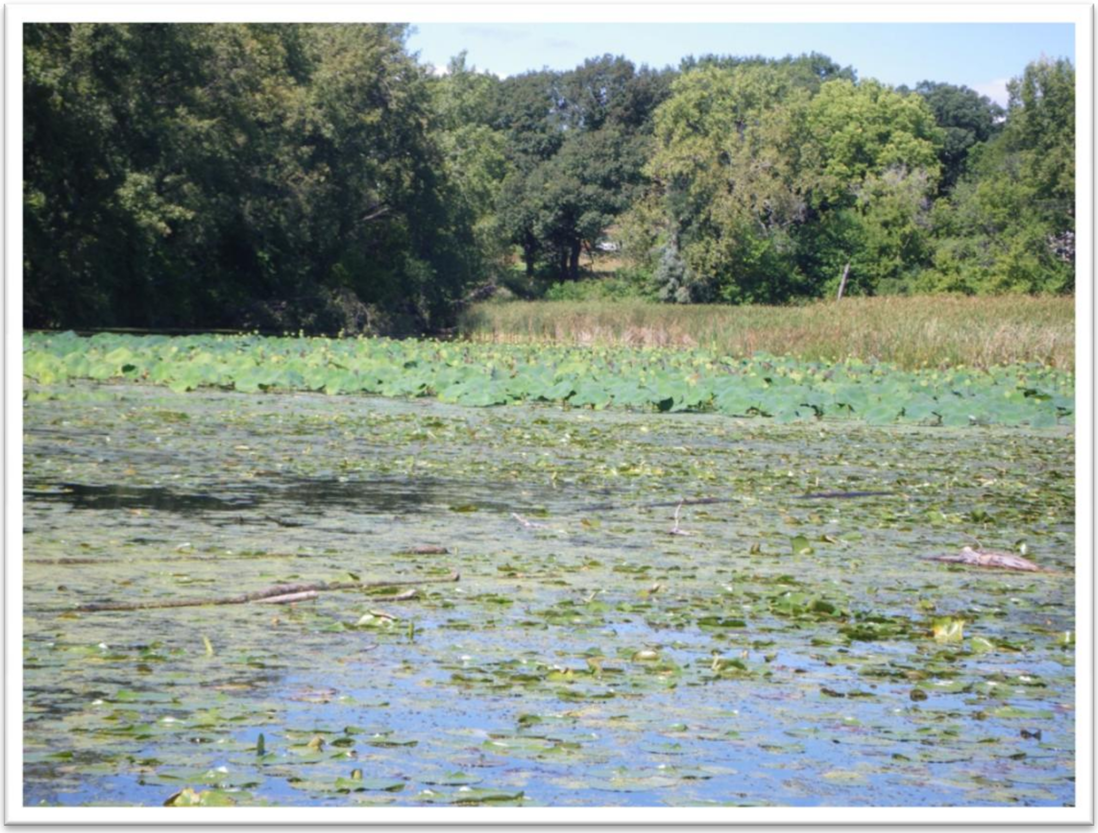
Wild Warner, a local friends group, reports observing up to 120 species of birds around the lagoon and associated wetlands at their website. On September 16th, we observed duck species, abundant Canada geese, great blue heron, Sandhill cranes, grebes and basking turtles on the numerous tree falls.

At the outlet to Lake Mendota, the Swoffer velocity meter did not detect water movement. A slight surface current appeared to move from the lake into the lagoon and this may be an estuary effect indication. An estuary effect may explain the slightly better water quality and higher specific conductance measurements in the south part of the lagoon.

Photo 1: Juvenile bluegills and largemouth bass collected 9/16/14

Photo 2: Juvenile common carp (4”) collected on September 16, 2014

Photo 3: Abundant floating-leaf plants in shallow water areas of the lagoon



Discussion

Historical perspective: An 1861 plat survey map (Figure 9) of Westport identifies a wetland, adjacent to Warner Bay in Section 36 that would later be called Castle Marsh and Warner Park Lagoon. Rapid land use changes associated with European settlement were captured in the 1937 aerial photo (Photo 4) with intensive agriculture surrounding the wetland. The land use change from savanna/prairie to farming significantly increased nutrient and sediment loading to the wetland. The WILMS predicted average annual phosphorus loading rate, after converting native vegetation to croplands, was increased an order magnitude (0.1 kg P/ha/yr to 1.0 kg P/ha/yr).

WDNR files document some of changes that occurred since the 1950's. By the mid to late 1950's, the Wisconsin Conservation Department and partners had been managing Castle Marsh for northern pike spawning and wildlife. Management problems identified at that time included low D. O. levels and nuisance common carp. A 1956 fish survey data revealed that common carp were the dominant species in Castle Marsh. That same year, a mosquito control effort in the wetland took the form of toxic DDT applications. By the early 1960's, conversion from agriculture to development was well underway. An agreement was established between the City of Madison and Wisconsin Conservation Department to use the wetland for development drainage management and for Lake Mendota protection. Conversion from agriculture to high density urban can increase phosphorus loading from 1.0 kg P/ha/yr to 1.5 kg P/ha/yr. Significant hydrological changes resulted from land disturbances, stormwater management and Castle Marsh dredging. Degraded environmental conditions in the lagoon reflect these collective land use changes.

Major winterkills were observed in 1970 (WDNR files), 1999 (M. M. School District "Stewards of the Lake" report) and 2007 (see WSJ photo 5). The water quality degradation that occurs in the lagoon today, along with periodic winterkills, reflect over a century of land use changes. Under anoxic conditions, the lagoon becomes a source of phosphorus to Lake Mendota due to internal loading and excessive Cyanobacteria blooms. In some respects, the existing trapping efficiency of Warner Park Lagoon achieves the goal established by the City and Conservation Department to protect Lake Mendota in 1961.

More currently, the City in cooperation with WDNR have targeted runoff pollution to protect the lagoon, with some of the proposed efforts captured in the Northport-Warner Park-Sherman Neighborhood Plan (2009). Without watershed management efforts, the SLAMM model estimates that the annual phosphorus and sediment loads to the lagoon would be 851 and 343,940 pounds respectively. However, management efforts underway have already resulted in significant pollutant load reductions to the lagoon. The SLAMM model also predicts that significant pollutants levels are deposited in the lagoon as opposed to discharge into Lake Mendota. The SLAMM (Source Loading and Management Model for Windows) model was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology. The model determines the runoff from a series of normal rainfall events and calculates the pollutant loading created by these rainfall events. The user is also able to apply a series of control devices, such as infiltration/biofiltration, street sweeping, wet detention ponds, grass swales, porous pavement, or catchbasins to determine how effectively these devices remove pollutants.

Figure 9: 1861 Westport Plat Map

Photo 4: 1937 Aerial Photo

Management Implications

The combination of historic land use changes and water quality data suggest that environmental degradation in Warner Park Lagoon did not happen overnight but rather occurred over many decades. Management efforts should focus on source controls (infiltration, street sweeping, etc.), managed detention or catch basins, and inlake management. The latter aspect is the primary focus of the management alternatives analysis below but must be used in concert with pollutant loading reductions. Inlake management efforts should focus on shifting the lagoon from a turbid Cyanobacteria state to a clear water alternative stable state (Hilt et al. 2011), maintain winter dissolved oxygen levels to prevent winterkill, reduce internal phosphorus loading and eliminate or significantly reduce common carp. A clear weedy stable state will be required to maintain a desirable Centrarchidae fishery. A comprehensive restoration plan would ultimately focus on reducing runoff pollutants to the lagoon. Part of this effort could focus on providing greater protection the south bay that displays more favorable water quality, while reducing impacts to other parts of the lagoon. Lake Mendota would benefit from efforts to protect the south bay as well. Specific management alternatives are discussed below and can be considered singularly or collectively. The collective efforts could provide greater protections for Lake Mendota.

Photo 5: Wisconsin State Journal Photo of Warner Park Lagoon 3/27/07, (Craig Schreiner), "*Another Sign of Spring*"

Preliminary Alternatives

1. Do nothing: Water quality impairments will continue including winterkills, severe Cyanobacteria blooms and internal phosphorus loading. Winterkills often benefit common carp (Bajer and Sorenson 2009) and other environmentally tolerant fish species that can reduce pollutant trapping effectiveness of stormwater ponds (McComas and Stuckert 2011).
2. Aeration: Winter aeration must be considered if the goal is to reduce winterkills. The relatively shallow lagoon in combination with nutrient rich sediments will prevent a sustainable sport fishery in the lagoon. Figure 10 displays two potential areas for aeration. Pond aeration systems can cost around $4,000 with an average operating cost of $51/month (http://www.thepondguy.com/product/airmax-lake-series-aeration-systems/airmax-aeration-systems). "Green" solar aeration systems can also be used in ponds up to 5 acres at a cost of less than $14,000 (http://www.livingwateraeration.com/sopopoae5ac.html) or

(http://www.solaraerator.com/). The solar aeration system or even wind generated aeration could be evaluated for the south bay that is more remote from the existing electric grid. Aeration is part of the Indian Lake (County Park) restoration planning along with common carp eradication and restoring the lake to a "weedy" clear water state. In Warner Park Lagoon, aeration can be used to protect native fish populations, manage the effects of stormwater inputs and also reduce internal loading if operated during summer months.

3. Drawdown: Water level drawdown is often used in lakes and ponds to control unwanted macrophytes (Cooke et al. 2005). Alternatively, improving Warner Park Lagoon should actually include increasing aquatic plants to shift the lagoon from a turbid to clear water state. The drawdown in this case could be used for common carp control as well as potentially enable other restoration strategies that may require low water or a dry bed for construction. Following a watershed diversion of 99.9% of pollutants that previously entered the restored Lake Belle View off-channel lake, common carp pose a significant environmental setback for the project and remain a formidable challenge toward complete lake restoration (Marshall and Wedepohl 2013, Kahler 2014). Most drawdowns are easily managed on impoundments by opening the outlet gates. But since the lagoon is the same elevation as Lake Mendota, constructing a temporary cofferdam and pumping (to Lake Mendota) would be required. Assuming a lagoon volume of about 3,590,040 cubic feet of water, pumping water at 1 cfs (0.65 MGD – million gallons per day) would take about 42 days without additional water inputs. Immediate effects of drawdowns are variable and can negative affect some macrophyte species and temporarily increase sediment phosphorus release after refilling (Cooke et al. 2005). The drawdown could also shift the lagoon to a clear water state since macrophytes can increase in some circumstances, including Eurasian watermilfoil and coontail that currently grow in the lagoon at low densities. In case studies, white waterlilies increased after 26 drawdowns, decreased after 14 drawdowns and remained about the same after 12 drawdowns (Cooke et al. 2005).
4. Dredging: Excavation can be used to remove polluted sediments and improve fish habitat and frequency of winterkill. The recent Lake Belle View restoration involved extensive dredging at a cost of $9/cubic/yd (MARS 2009). Two possible dredging sites are identified in Figure 10. Assuming total dredging area of 2.5 acres and removing an average of 6' sediment, or 24,200 cubic yards, the cost would be approximately $218,000. A more aggressive dredging operation of approximately 20 acres at 6' sediment depth, or 193,600 cubic yards, would cost roughly $1.74 million. The latter far more expensive alternative could significantly reduce a sediment pool of phosphorus and other pollutants in the lagoon. Under the modest dredging scenario, deeper pools could provide open water if the lagoon shifts to a macrophyte dominated ecosystem and provide habitat can attract fish populations. Sediment testing conducted by the City of Madison demonstrated that the lagoon holds polluted sediments but are not considered

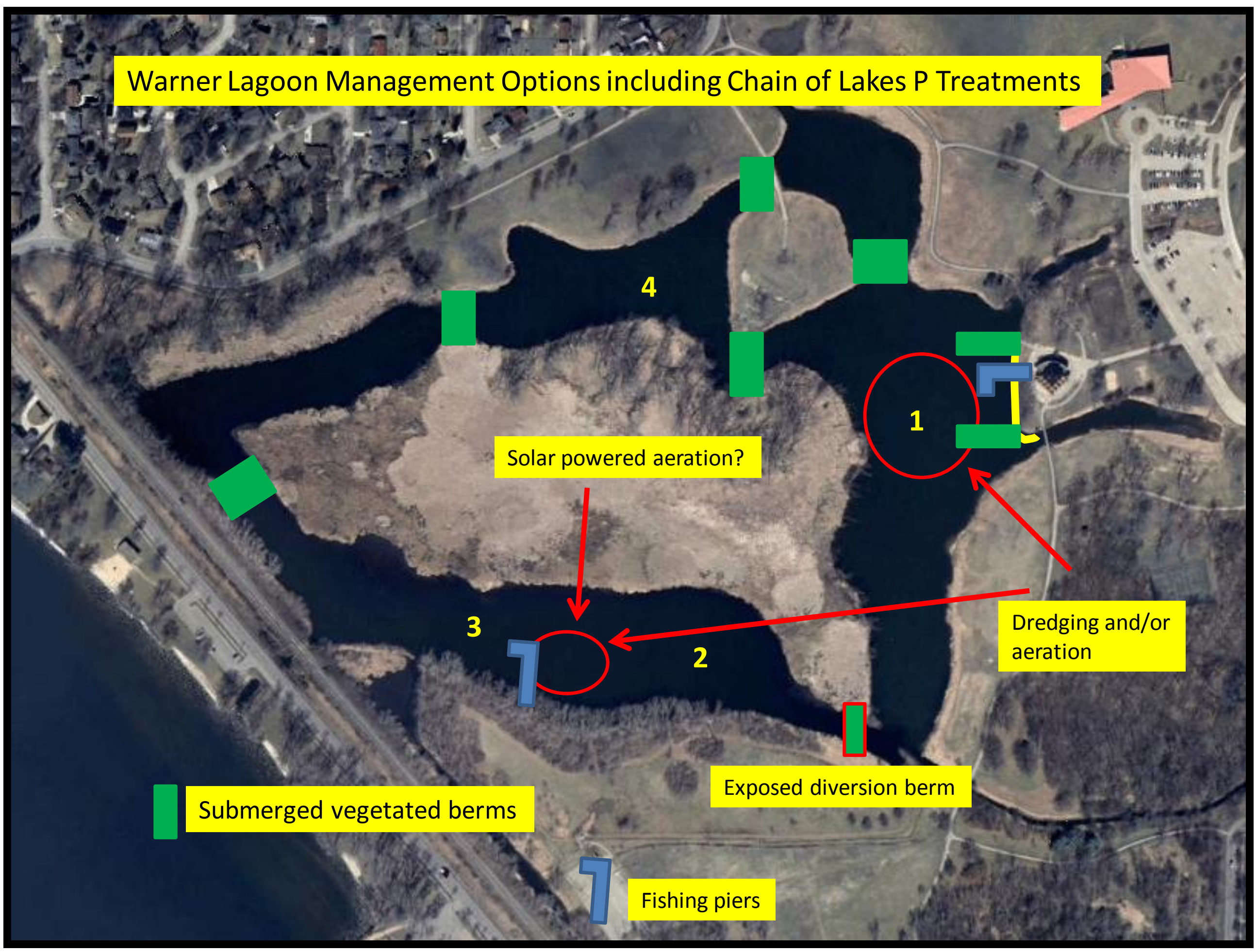
hazardous (Bemis 2012). However, chlorinated hydrocarbons were not tested and the record of DDT application(s) is of concern. Additional testing will likely be required under Wisconsin Administrative Code NR 347 to assess additional potential pollutant concentrations and disposal options. https://docs.legis.wisconsin.gov/code/admin_code/nr/300/347.pdf

5. Dilution/flushing: Water could be pumped from Lake Mendota to establish a clear water state. This effort could cease after macrophytes expand across the lagoon. Similar to the drawdown option, the lagoon could be residence time in the lagoon would be 42 days if water is pumping from Lake Mendota at 1 cfs.
6. Inlake diversion and "Chain of lakes" effect: A number of berms can be placed in the lagoon to channel water in a counter clockwise direction to protect the south bay and provide greater assimilation of nutrients before reaching Lake Mendota. As proposed in Figure 10, a surface exposed berm would direct stormwater from the southeast away from the south bay and to the northwest. A serious of shallow water berms or reefs would segment the lagoon into a series of pools. The shallow reefs would be vegetated with white water lilies and other aquatic plants to expand fish habitat. As primary producers, the rooted plants and attached periphyton could compete for nutrients with Cyanobacteria and provide a refuge for zooplankton (Jeppesen et al. 1999). This scenario has potential for additional nutrient load reductions to Lake Mendota while protecting the south bay. For example, as part of the Rock Lake (Jefferson County) water resources appraisal a chain of shallow lakes model predicted reduced phosphorus loading to Rock Lake (Marshall et. al. 1997). Preliminary estimated cost of installing a diversion berm and reef berms (about 800 x 20 feet) is $79,000 using the Lake Belle View model cost estimates.
7. Phosphorus inactivation: Alum (aluminum salt) has been gaining acceptance in Dane County for reducing watershed phosphorus loads. Inlake treatments are designed to remove phosphorus from the water column by co-precipitation as well as retard release from sediments. This technique can be effective if external loads are controlled. In Washington State, alum treatments in shallow unstratified lakes were largely successful because external phosphorus loading was significantly reduced. Given that the watershed to lagoon surface area is relatively large at approximately 14:1 and mostly urbanized, significant phosphorus loading will continue even assuming that best management practices in the watershed are in place. However, an alum treatment could be used as a single effort to shift the lagoon from turbid to clear water conditions. Otherwise, recurrent applications would be needed and care must be taken given the potential toxic effects as described in Cooke et al. 2005 in some detail. An alternative form of phosphorus inactivation is the application of calcite ($CaCO_3$) that is a natural carbonate mineral that co-precipitates with phosphorus in marl lakes and a primary reason why most marl lakes are clear (Sondergaard et al 2003).
8. Mechanical harvesting: Warner Park Lagoon is currently managed under the Dane County Parks Aquatic Plant Harvesting Program and WDNR Aquatic Plant Management

Program permit (Marshall et al. 2007, Jones 2014). If a successful shift from turbid to clear water state occurs, dense macrophyte growths in the forms of coontail, curly-leaf pondweed and Eurasian watermilfoil would like occur. These can be managed under this program.

9. <u>Combination of alternatives</u>: Figure 10 displays an array of alternatives that can be combined for greater potential project success. Aeration would ensure sport fish survival in the winter. Dredging near fishing piers could concentrate fish to improve angling opportunities. The lagoon stormwater diversion and treatment pools with reefs could result in greater retention of pollutants, improve fish habitat and protect the south bay and Lake Mendota.
10. <u>Nutrient/sediment input reductions</u>

Figure 10: Warner Park Lagoon Restoration Option



Alternative K9: Retriever (owner) training. This is a small sample of numerous tennis balls and other dog toys observed floating in the south bay.

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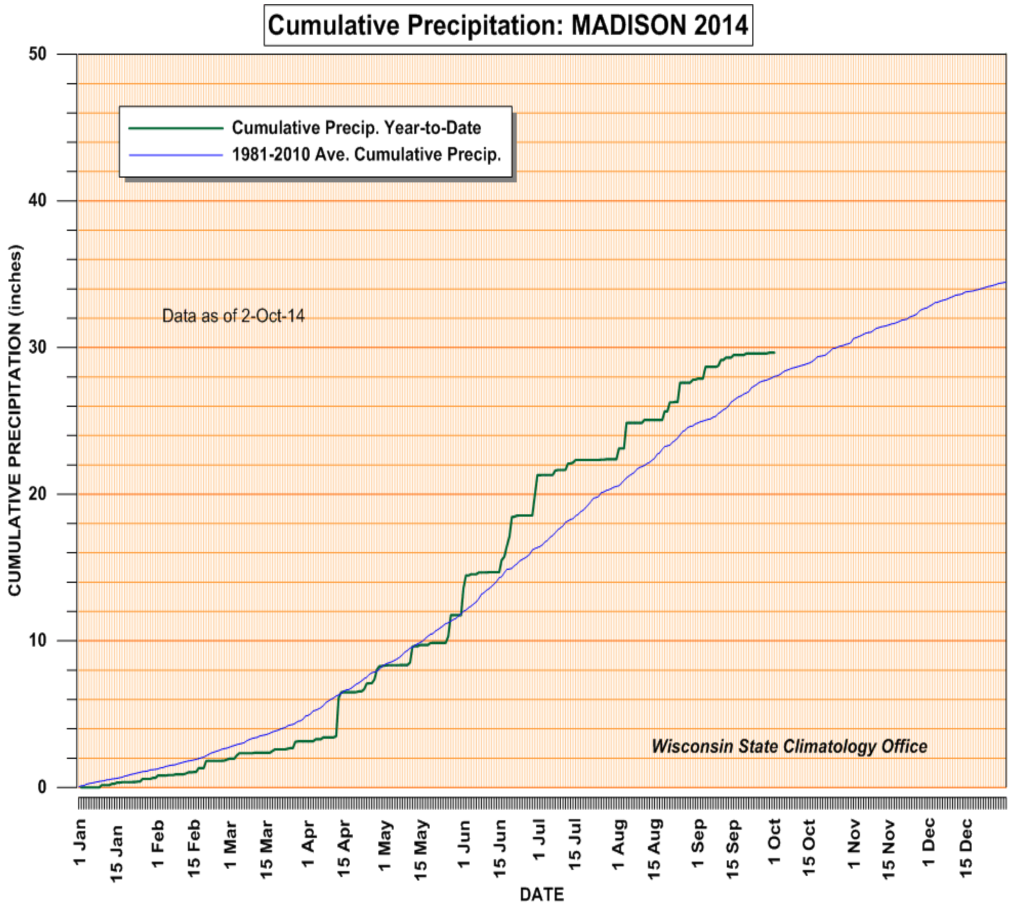

cc- E.F.H., N.G.M., A.R.E., C.L.B., E.E.O.

STATE OF WISCONSIN

CONSERVATION DEPARTMENT

ROUGH

DRAFT

Southern Area Headquarters
Route No. 2
Madison 5
August 7, 1961

Mr. Harold Starkweather
3158 Daley Drive
Madison, Wisconsin

Dear Mr. Starkweather:

Per your recent telephone request, the following is a review of the limited modifications completed and in process by the city of Madison Parks Department in Castle Marsh. Also included is a brief review of our tentative plans in general for the eventual coordinated development of Castle Marsh with the city of Madison Parks Department.

Since the Wisconsin Conservation Department ~~purchase~~ assumed the control in 1954, of this approximate 13-acre portion of Castle Marsh located in the town of Westport, the Department has enjoyed the full cooperation of the city of Madison Parks Department.

In 1956, the city proceeded to improve and further develop the Warner Beach area on Lake Mendota proper. During these activities, the city Parks Department cooperated with us to the fullest extent regarding the use of the marsh as well as the new marsh outlet by northern pike during the spawning run periods.

During May, 1956, approximately 10 acres in the aggregate of Castle Marsh was sprayed by the city of Madison with 60 gallons of fuel oil containing approximately 1.25 pounds of D.D.T. for the purpose of controlling mosquitoes.

CASTLE MARSH - DANE COUNTY

"Future Plans of City and Wis. Cons. Dept. are Compatable"

Met at Nevin, Thursday, January 19, 1961.

Jim Marshall and Art Johnson of City Parks Department; E. F. Herman, N. J. Miller, A. R. Ensign and E. E. Owen.

Fully discussed city plans on Castle Marsh meshing with WCD northern pike wishes - good results.

1) City to lagoon marsh for public recreation.

2) City to provide for upland development area drainage into marsh to protect Lake Mendota as much as possible.

3) Outlet channel of marsh to be opened into lake with a breakwater at mouth to keep it open.

4) WCD to work with city on marsh water level control and screening out undesirable species of fish.

5) WCD to operate entire lagoon areas for northern pike production.

City to cooperate as much as possible whenever needed.

6) WCD to install proper signs around marsh lagoons and outlet as needed.

4-6-61
ah