Report

Phase I - Lagoon Water Quality Evaluation

Scope ID: 00G003

LPL-681-00

Bay Beach Wildlife Sanctuary
Green Bay, Wisconsin

June 2001

Foth & Van Dyke

consultants · engineers · scientists

Bay Beach Wildlife Sanctuary
Phase I - Lagoon Water Quality Evaluation

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1 Executive Summary

Foth & Van Dyke was retained by the City of Green Bay to conduct a water quality evaluation of the Bay Beach Wildlife Sanctuary lagoons. The City received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) which provided funding up to $10,000 for this project.

This evaluation and report focused on evaluation of the current trophic status including water quality data generation, the relationship to the land use practices in the Bay Beach lagoon watershed to the water quality of the lagoon, and the impacts of waterfowl the water quality of the lagoon.

Water Quality

A water quality sampling program was implemented to determine the lake's water quality and trophic status. The Bay Beach lagoon can be described as highly eutrophic based on the high concentrations of phosphorus and algae. Other parameters such as dissolved oxygen and water clarity were also typical of highly eutrophic lakes.

Lagoon Sediment

Sediment in the lagoon was noted up to 4 feet thick in some places. Based on sediment measurements, it is estimated that the lagoon contains over 39,000 cubic yards of sediment. The sediment contains significant amounts of organic matter, Biochemical Oxygen Demand (BOD), and phosphorus. The organic matter which is measured in the BOD analysis can reduce the dissolved oxygen in the lagoon. The phosphorus in the sediment can be brought back in to the water column promoting algae growth.

Watershed Analysis

The watershed associated with the lagoon is 283 acre in size. Less than 20% of the area is developed. Other uses are forests and grasslands. The result is little impact from the watershed on the lagoon with an estimated 8 pounds per year of phosphorus contributed to the lagoon.

Waterfowl Impacts

Large numbers of resident and migratory waterfowl use the lagoons for a resting area. Peak populations of over 7,000 Giant Canada geese and over 4,000 mallard ducks use the sanctuary with about ⅔ of the total using the main lagoon. This results in 57 tons of fecal matter including over 1,700 pounds of phosphorus being added each year by waterfowl. The impact from waterfowl is significantly greater than any other impacts on the water quality of the lagoon.

Recommendations

It is recommended that the City of Green Bay proceed with the following:

- Evaluate methods of providing oxygen to the lagoon at all times
- Evaluate methods of removing sediment from the lagoon
- Evaluate methods of reducing the impacts of waterfowl on the lagoon
- Evaluate methods of reducing the phosphorus concentration in the lagoon.
- Complete a lake management plan toward maintaining and protecting the water quality of the lagoon

2 Introduction

The Bay Beach Wildlife Sanctuary lagoons are located in the City of Green Bay, Brown County, Wisconsin. The lagoons cover an area of 42 acres with the main lagoon having a surface area of 14.9 acres, a maximum depth of 12 feet, and an average depth of 4.1 feet.

In April 2000, the City of Green Bay was awarded a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a study of the water quality of the Bay Beach Wildlife Sanctuary lagoons. While 42 acres of lagoons are present at the wildlife sanctuary, the primary emphasis for this study was on the largest individual lagoon, a single 14.9 acre water body.

2.1 Authorization

The City of Green Bay authorized the consulting firm of Foth & Van Dyke to complete Phase I of the lagoon study for the Wildlife Sanctuary, and to prepare a report identifying the results. The study resulted in a collaborative effort among Foth & Van Dyke, the Bay Beach Wildlife Sanctuary staff, volunteers, and WDNR personnel.

2.2 Purpose

The purpose of the Phase I lake study was to address the following areas.

- Obtain water quality data to establish the existing water quality of the 14.9 acre lagoon.
- Determine the quantity and quality of sediment in the lagoon.
- Complete an analysis of the land use and associated phosphorus runoff in the lagoon's immediate watershed.
- Determine the extent to which the waterfowl population impacts the lagoon.

The results of this study will be used to provide the City with an understanding of the water quality of the lagoons and potential sources of nutrients. This report will be used as a basis for a Phase II study which will evaluate alternatives to allow the lagoon to be used as a fishery.

2.3 Project Study Area

Figure 2-1 illustrates the project study area, including the water quality sampling location.

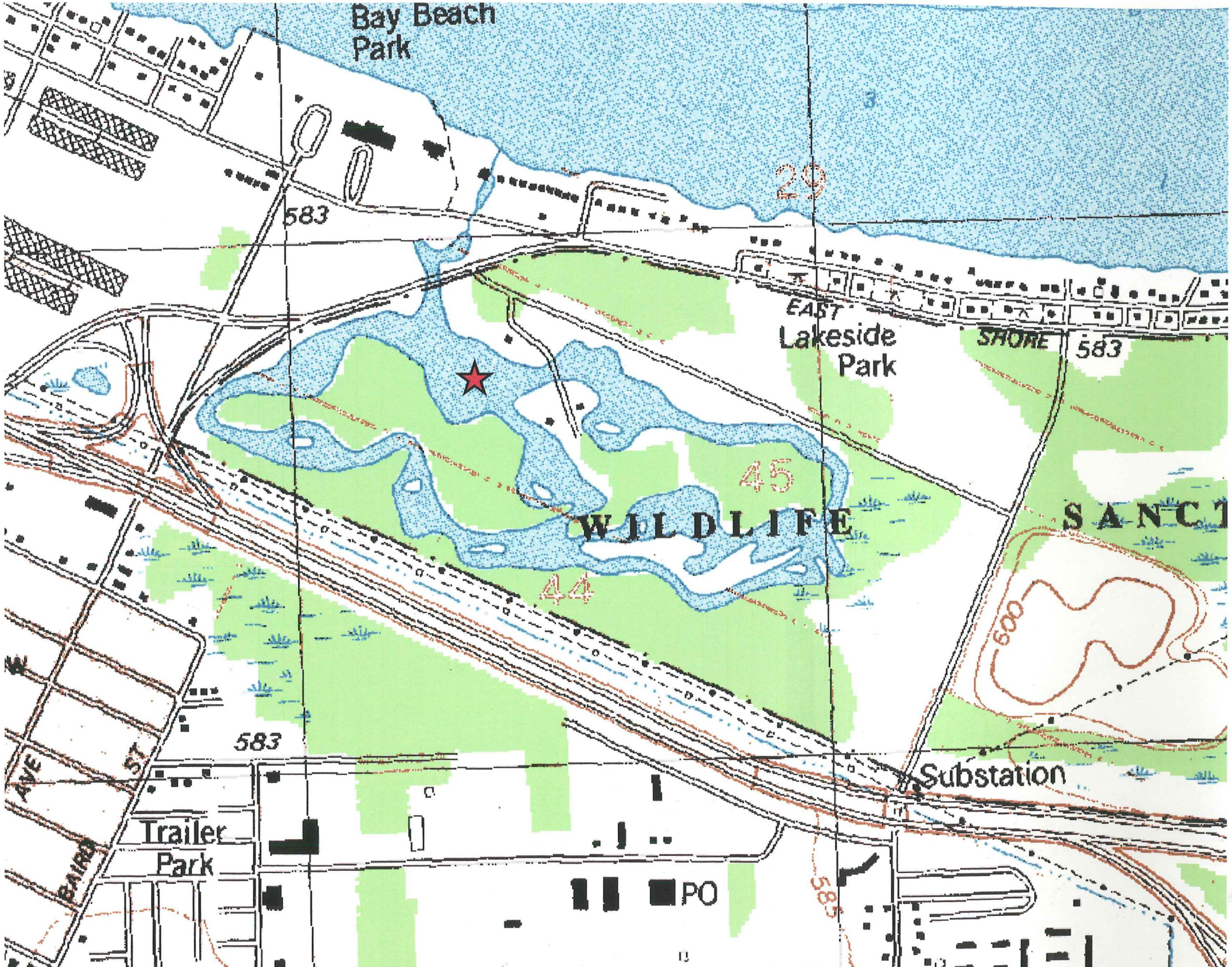

FIGURE 2-1
STUDY AREA
Bay Beach Wildlife Sanctuary
Brown County, Wisconsin

State of Wisconsin

★ Sampling Location

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5-minute topographic quadrangle - School Hill (1973).
Classification derived from LANDSAT Thematic Mapper (TM) satellite imagery from 1991, 1992, and 1993.
The classification has been smoothed to a one acre minimum mapping unit (4 contiguous pixels) from the original 30-meter pixel size.
Wetlands less than one acre and open water pixels were not smoothed.
Classification was done by the Wisconsin DNR - Geo Services Section.
Watershed delineation done by Foth and Van Dyke, 2000.

0 200 400 600 800 1000 Feet

N

Foth & Van Dyke
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M:\00g003\apr\baybeach2.apr April 29, 2001 Drawn by: kpk1 Checked by: pak

3 Water Quality

The water quality of a lake is dependent upon a number of factors and lake characteristics. Every lake possesses a unique set of physical and chemical characteristics that may change over time. The chemical changes occur on a daily basis, while physical changes (such as plant and algae growth) occur on a seasonal basis. Seasonal changes in the physical characteristics of a lake are common because factors such as surface runoff, groundwater inflow, precipitation, temperature and sunlight are variable. A lake's water quality will vary with the seasonal changes, therefore data must be gathered over a period of time to accurately determine if a lake is experiencing significant changes in water quality and to distinguish between natural variability and human activity impacts.

To determine the water quality and trophic status of the main Bay Beach Wildlife Sanctuary lagoon, a sampling program was devised which included testing numerous characteristics of the lagoon over time. The following section explains the sampling program and its components, presents the results and analysis of the sampling conducted, and provides conclusions about the water quality of the lagoon. First, however, it is important to identify the natural aging process experienced by lakes/lagoons (eutrophication), and the source of the lake's water supply as this contributes to the factors which affect the quality of its water supply. In addition, identification of the water source allows for sound management practices to be selected consistent with the specific characteristics of the lake.

Eutrophication - The Aging Process

The process of eutrophication is a natural aging process which occurs in all lakes whereby a lake progresses from a more oligotrophic (young lake) to a more eutrophic (old age) state. When nutrients such as phosphorus and nitrogen wash into a lake with stormwater or by soil erosion, they fertilize the lake and encourage algae and larger plants to grow. As plants and the animals that feed on them die and decompose, they accumulate on the lake bottom as organic sediments. After hundreds or thousands of years of plant growth and decomposition, the character of a lake may more closely resemble a marsh or a bog.

Lakes also obtain nutrients from various human activities which can literally make a lake old before its time. This accelerated transition is commonly termed "cultural eutrophication", whereby changes that would normally take centuries may occur over/within one person's lifetime. Nutrients from agriculture, stormwater runoff, urban development, lawn and garden fertilizers, failing septic systems, land clearing, construction site runoff, municipal and industrial wastewater, and recreational activities contribute to the accelerated eutrophication or enrichment of lakes.

The practices which attract and hold waterfowl in this area can also be considered a cultural activity which can be directly linked to "cultural eutrophication."

Trophic Status Indicators

The trophic state of a water body is an indicator of the nutrient levels and water clarity in a lake. Lakes can be divided into three categories based on their trophic state which include oligotrophic, mesotrophic, and eutrophic. The following provides a description of each trophic state:

Oligotrophic: Young lakes with low productivity which are generally clear, cold, deep, and free of weeds or large algae blooms. Oligotrophic lakes are low in nutrients and therefore do not support plant growth or large fish populations, however are capable of sustaining a desirable fishery.

Mesotrophic: These lakes are in an intermediate stage between the oligotrophic and eutrophic stages. They are moderately productive, supporting a diverse community of native aquatic plants. The bottoms of mesotrophic lakes lack oxygen in late summer months or winter periods which limits cold water fish and causes phosphorus cycling from sediments. Overall however, mesotrophic lakes support good fisheries.

Eutrophic: Lakes which are high in nutrients and support a large biomass are categorized as eutrophic. These old age lakes are usually weedy and/or experience large algae blooms. Most often they support large fish populations, however are also susceptible to oxygen depletion which limits fishery diversity. Rough fish are common in eutrophic lakes.

The trophic state of a lake can be determined by observing three lake characteristics including total phosphorus concentration (Total-P) which indicates the amount of nutrients present which are necessary for algae growth, Chlorophyll *a* concentration which is a measure of the amount of algae actually present, and Secchi disc readings which is an indicator of water clarity. As expected, low levels of Total P are related to low levels of Chlorophyll *a*, which are related to high Secchi disc readings.

To determine the trophic state of the lake, the Wisconsin Trophic State Index (WTSI) can be applied to each of the above noted factors. The WTSI converts the actual measurement into a value which is representative of one of the trophic states. Values less than or equal to 39 indicate oligotrophic conditions, values from 40-49 indicate mesotrophic conditions, and values equal to or greater than 50 represent eutrophic conditions.

General Characteristics of the Bay Beach Wildlife Sanctuary Lagoons

The Wildlife Sanctuary lagoons are classified as manmade seepage lagoons: a seepage lagoon is a manmade lagoon fed by precipitation, limited runoff and groundwater. In this case the lagoon was created by the City and maintains its water level from groundwater infiltration, two water wells that contribute 50 gpm of water to the lagoon (Szymanski, 1999), and direct precipitation. Runoff is also a source of water to the lagoon. Lagoon water quality is most influenced by runoff which is impacted by the drainage basin and the land use in that basin. Within the drainage basin and land use practices resides the presence and resulting impact of concentrated waterfowl populations.

The main lagoon has a surface area of 14.9 acres with an average depth of 4.1 feet and a maximum depth of 12 feet. The watershed associated with the Wildlife Sanctuary lagoons covers 283.4 acres, a relatively small watershed.

3.1 Sampling Program

The sampling program used to evaluate the water quality of the main lagoon was conducted over approximately a ten month time period, beginning in May of 2000, and concluding in February 2001. This sampling program provided information to evaluate the current water quality of the lagoon. Sampling was conducted on five separate occasions including:

- May 2000
- June 2000
- July 2000
- August 2000
- February 2001 (ice-on)

Bay Beach Wildlife Sanctuary staff and Foth & Van Dyke personnel performed the water sampling, while laboratory analysis of the samples was completed by the State Laboratory of Hygiene. It was important to obtain samples with ice on, and in summer months to obtain data representative of the seasonal changes which can affect water quality.

Numerous factors were considered in the sampling program, including:

Dissolved Oxygen (D.O.)	Temperature	Chlorophyll *a*
Total Phosphorus	Orthophosphate	pH
Ammonia Nitrogen	Nitrate plus Nitrite Nitrogen	
Total Kjeldahl Nitrogen	Secchi Disc readings	

These factors were measured at a single sample location. Temperature and D.O. were measured at various depths in the lagoon ranging from surface to subsurface. As the primary objective of this study was to determine the trophic status of the Bay Beach Wildlife Sanctuary lagoons, the factors which contribute to making this determination were sampled more frequently than most other factors. These factors include total phosphorus (Total P), Chlorophyll *a*, and Secchi Disc readings. For the purposes of this study, dissolved oxygen, pH, and temperature were also sampled on all sample dates.

The following section provides the results of the sampling program, highlighting the those factors which contribute to the determination of the lagoon's trophic state,

3.2 Results and Analysis

The complete results of the sampling program conducted on the Wildlife Sanctuary lagoon are displayed in Appendix A. The following section provides a more detailed discussion of the sampling results of temperature, dissolved oxygen levels, trophic status indicators including total phosphorous concentrations, Chlorophyll *a* concentrations, and Secchi disc readings.

3.2.1 Temperature

Temperature exerts a major influence on biological activity and growth. To a point, the higher the water temperature, the greater the biological activity. Temperature also governs the kinds of organisms that can live in a lake. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below this preferred range, the survival of individual species may be limited or eliminated.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it is more difficult to maintain enough oxygen in warm water for survival of aquatic life.

Stratification is a layering effect produced by the warming of the surface waters in many lakes in the summer, during which time lake water separates into layers of distinctly different temperature. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because the layers don't mix, they develop different physical and chemical characteristics, often resembling two different lakes. As a result, oxygen in the bottom waters may become depleted. In autumn, as the upper waters cool to about the same temperature as the lower water, stratification is lost and the whole lake mixes, balancing the lake's chemistry. This process is called fall turnover. Many lakes experience stratification in winter because ice covers the lake surface. In the winter, however, the warmer water is near the bottom. In spring, as ice melts, the water temperatures once again equalize and mixing occurs, a process called spring turnover. As summer progresses, the temperature difference (and density difference) between surface and bottom water becomes more distinct, as mentioned previously, and most lakes form three layers. The upper layer, the epilimnion, is characterized by warmer (less dense) water and is the zone of light penetration, where the bulk of productivity or biological growth occurs. The next layer, the metalimnion or thermocline, is a narrow band where the transition from warmer surface waters goes to the cooler bottom layer. This transition zone helps to prevent mixing between the upper and lower layers. The bottom layer, the hypolimnion, has much colder water. Plant material either decays or sinks to the bottom and accumulates in this isolated layer.

A shallow lake, however, is more likely to be homogeneous from top to bottom. The water is well-mixed by the wind and current, and physical characteristics such as temperature (and oxygen) vary little with depth. Because sunlight reaches all the way to the bottom, photosynthesis and growth occur throughout the water column. As in a deep lake, decomposition in a shallow lake is higher near the bottom than the top simply due to the fact that when plants and animals die they sink. It is also likely that a larger portion of the water in a shallow lake is influenced by sunlight, and that photosynthesis and plant growth are proportionately higher.

3.2.1.1 Temperature Profile of the Bay Beach Wildlife Sanctuary Lagoon

Temperature profiles of the main 14.9 acre lagoon were taken at a single location. The data collected shows that the lake experienced slight stratification during the summer months from June through early August with a 10.5° C (51° F) variation. The water was less stratified throughout the remaining months of the study.

3.2.2 Dissolved Oxygen (D.O.) Concentration

The presence of oxygen in lake water determines where organisms such as fish and zooplankton are found. When water is well-mixed, such as in spring, oxygen is usually present at all depths, thus organisms may be distributed throughout the lake. However, under stratified conditions, little or no oxygen is produced in the hypolimnion. Available oxygen is consumed through decomposition of plant and animal material, and oxygen levels become too low for fish which then must move to the top layer, or epilimnion. If these conditions are prolonged and the upper waters become too warm, cold-water fish such as trout may become stressed and eventually die. In the fall, the lake layers break down and turnover replenishes oxygen to the bottom waters. The formation of an ice cap on the water reduces the supply of oxygen to the lake from the overlying air. If oxygen levels fall too low, fish and other aquatic life may die.

The concentration of dissolved oxygen (D.O.) present in a lake is important as it supports aquatic life. The solubility of oxygen depends on the temperature of the water - colder water holds more oxygen than warmer water. The amount of D.O. present in lakes at different times of the day, and at different depths, is largely determined by the processes of photosynthesis and respiration. Oxygen is produced when green plants grow (photosynthesis), and is consumed through respiration. Therefore, D.O. levels tend to be higher during daylight hours (when photosynthesis occurs), and lower at night/early morning. In addition, lake depths which are below the reach of sunlight may experience oxygen depletion. Oxygen depletion is especially apparent in winter months where snow cover prevents sunlight from penetrating the water, stopping photosynthesis and causing plants to die; this is termed "winter kill" and occurs in many eutrophic lakes.

In warm water, the water quality standard for D.O. is 5 mg/l, which represents the minimum amount needed for the survival and growth of warm water fish species. D.O. concentrations between 8 mg/l and 12 mg/l indicate oxygen saturation.

3.2.2.1 Dissolved Oxygen Lagoon Results

The D.O. levels in the lagoon vary greatly among the varying sample dates and depths ranging from approximately 0.1 mg/l to 19 mg/l. The upper 3 or 4 feet had consistently high D.O. levels in the open water samples. The high D.O. concentrations are caused by the algal photosynthesis which releases oxygen into the water. Below this upper water level the oxygen concentrations dropped quickly with the lower levels of the lagoon showing oxygen concentrations below 1.0 mg/l. When the lagoon is ice covered, D.O. concentrations drop below 1.0 mg/l for almost the entire water column. The low D.O. concentrations prevent fish from surviving in the lagoon and impact other aquatic organisms as well. A graphic illustration of the D.O. and Temperature stratification is shown below. This data illustrates the conditions in the Lagoon on May 2, 2000.

3.2.3 Trophic Status Indicators

3.2.3.1 Total Phosphorus Concentration (Total P)

Phosphorus is the key nutrient which influences plant growth in over 80% of the lakes throughout Wisconsin. Excess phosphorus promotes excessive aquatic plant growth. In most lakes, phosphorus is the least available nutrient, so it's abundance, or scarcity, controls the extent of algae growth. For that reason, phosphorus is typically referred to as the limiting nutrient. If more phosphorus is added to the lake from septic tanks, urban or farmland runoff, lawn or garden fertilizers, sewage treatment plants, or other watershed or outside resources, or even if it is released from phosphorus-rich lake bottom sediments, that limitation is taken away and more weeds and algae will grow. Under certain conditions, especially when oxygen is absent from bottom waters, phosphorus is released from bottom sediments into the overlying water. In turn, algae clouds water clarity and decreases the depth of light penetration.

Algae and weeds are a source of food and energy for fish and other lake organisms, and are a vital part of all lakes. However, excessive amounts or nuisance types of algae or weeds can interfere with lake uses by inhibiting the growth of other plants by clouding the water so that it shades them, contributing - as the decay - to oxygen depletion and fish kills, and causing taste and odor problems in water and fish. In addition, it can interfere with the aesthetic environment of the lake causing unsightly algal blooms which float on the lake surface forming scums. The regular occurrence of visible algal blooms often indicates that nutrient levels, especially phosphorus, are too high.

Aquatic plants may also limit many lake uses. Although aquatic plants (macrophytes) serve a vital function for the lake by providing cover, habitat, and even food for fish and other wildlife, an overabundance of rooted and floating plants can limit swimming, fishing, skiing, sailing, and boating activities, and aesthetic appreciation. Excessive plant growth can physically prevent mixing of oxygen through the water.

Two types of phosphorus analyses can be conducted which include soluble reactive phosphorus (orthophosphate) and total phosphorus. Total phosphorus is often a better indicator of the nutrient status of a lake because its levels remain more stable. The concentrations of Total P detected at the sample points and the corresponding Wisconsin Trophic Status Index (WTSI) values are presented in Table 3-1.

Table 3-1
Total Phosphorus Levels
Bay Beach Wildlife Sanctuary Lagoon

Average Total P ug/l	980
Range Total P ug/l	489-1,310
Average WTSI	81

The total phosphorus data indicates that the Bay Beach lagoon is in an extremely eutrophic category for lakes.

The WDNR guide Understanding Lake Data shows that an average total phosphorus concentration for impoundments is 70 ug/l and for a natural lake is 25 ug/l. This guide also states that total phosphorus should be maintained below 30 ug/l for impoundment lakes in order to prevent nuisance algae blooms. As indicated in Table 3-1, the total P concentrations in the lagoon exceeded 30 ug/l at times of the year by a factor of 15 or more. The total phosphorus concentrations in the Bay Beach Wildlife Sanctuary lagoons are extremely high indicating an impaired water body.

3.2.3.2 Chlorophyll a Concentration

Chlorophyll *a* is a green pigment which is present in all plant life and is necessary for photosynthesis. The amount of chlorophyll *a* present in a lake is dependent upon the amount of algae present, and is therefore used as a common indicator of water quality. It is also one of three characteristics used to determine the trophic state of a lake. Table 3-2 identifies the concentration of Chlorophyll *a* detected in the main lagoon and the corresponding WTSI status.

Table 3-2
Chlorophyll *a* Levels
Bay Beach Wildlife Sanctuary Lagoon

Average Chl. a - ug/l	74.4
Range Chl. a - ug/l	42-148.9
Average WTSI	68

Based on the results of the Chlorophyll *a* samples, the trophic status of the lagoon was identified as being extremely eutrophic.

3.2.3.3 Secchi Disc Reading

A Secchi disc reading is a measure of water clarity; it is not a direct measure of water quality related to chemical and physical properties. However, water clarity is often indicative of a lake's overall water quality, especially the amount of algae present. Secchi disc readings are taken by lowering an 8 inch disc into the water, and taking the average of the depth where the disc disappears from sight and where it becomes visible again when raised. The Secchi disc reading can be used to determine the trophic state of a lake. Table 3-3 shows the average Secchi disc readings in the main lagoon and the corresponding WTSI status.

Table 3-3
Secchi Depth
Bay Beach Wildlife Sanctuary Lagoon

Average Secchi Depth - Ft.	0.9
Range Secchi Depth - Ft.	0.5-2
Average WTSI	82

These readings also indicate the lagoon's water quality is in the extremely euthrophic.

3.2.4 Non-Trophic Status Indicators

3.2.4.1 Nitrogen

Nitrogen is an important plant nutrient. While phosphorus is typically the limiting nutrient for algae growth, nitrogen can be limiting under some circumstances. Nitrogen compounds are present in lakes as inorganic or organic. The inorganic forms are ammonia and nitrite/nitrate ($NO_2 + NO_3$) and these forms are available to plants for growth. The organic form is included in Total Kjeldahl Nitrogen. This form is found in plant and animal tissues.

The data collected in the May 2000 sample shows relatively low values for inorganic nitrogen. The value for ammonia was 0.1 mg/l. In contrast, data collected by WDNR in 1998 show much higher ammonia concentrations with values up to 12.5 mg/l. Ammonia can be toxic to aquatic organisms in concentrations exceeding 5 mg/l.

3.3 Water Quality Conclusions

Temperature

The lake does have a strong stratification characteristic and has demonstrated varying temperatures for most of the year, meaning that the temperatures vary greatly from the top to the bottom of the lake. Because the lagoon remains stratified, oxygen is not distributed evenly throughout the lagoon for most of the year, as seen from the D.O. readings.

Dissolved Oxygen

Typical of eutrophic lakes, D.O. concentrations were lower at the bottom of the lagoon in summer and winter. The D.O. was depleted at depths greater than 3 or 4 feet for all samples. The D.O. concentrations were not adequate for survival of fish and other aerobic aquatic organisms.

Total Phosphorus

Concentrations of Total P were consistently in the eutrophic range. This was in complete agreement to the Chlorophyll a and Secchi disk readings which were also in the eutrophic range.

Chlorophyll a

Measurements of chlorophyll a were in the extremely eutrophic range and tended to increase later into the summer months.

Secchi Disc

The Secchi disc measurements were also in the eutrophic range. Water clarity decreases with an increase in algae growth. As the water clarity decreases, so does the size of the litoral zone, that area of a lake where the light penetration reaches the bottom. The litoral zone is the area that can support rooted macrophytes, an important component of the aquatic ecosystem.

Nitrogen

Ammonia concentrations from recent WDNR sampling events indicate high levels of ammonia in the lower levels of the lagoon. The high levels of ammonia may cause toxicity to aquatic organisms.

Water Quality Summary

The water quality parameters showed the main lagoon to be an extremely eutrophic water body for phosphorus and other parameters measuring algae growth. The phosphorus and nitrogen concentrations are both high enough to consistently encourage the excessive algae growth currently present in the lagoon. The D.O. is not adequate for fish survival and other aquatic life requiring an aerobic environment.

4 Sediment Analysis

Sediments can influence the water quality of the lagoons. Organic sediments from plant and animal life will decay on the lake floor consuming oxygen. Compounds such as ammonia and phosphorus are released as organic compounds decay. This cycle of decomposition can reduce oxygen levels and add nutrients to the water. The sediment of the main Bay Beach lagoon was tested for quality and to estimate the volume of sediment present in this lagoon. The primary source for organic sediments in the Bay Beach lagoon appear to be the waterfowl excrement.

4.1 Sediment Quality

Sediment samples were collected in June 2000. The samples were tested for BOD, phosphorus, and percent solids. The BOD averaged 376 mg/kg dry weight, phosphorus averaged 539 mg/kg dry weight and the percent solids averaged 51%.

4.2 Sediment Quantity

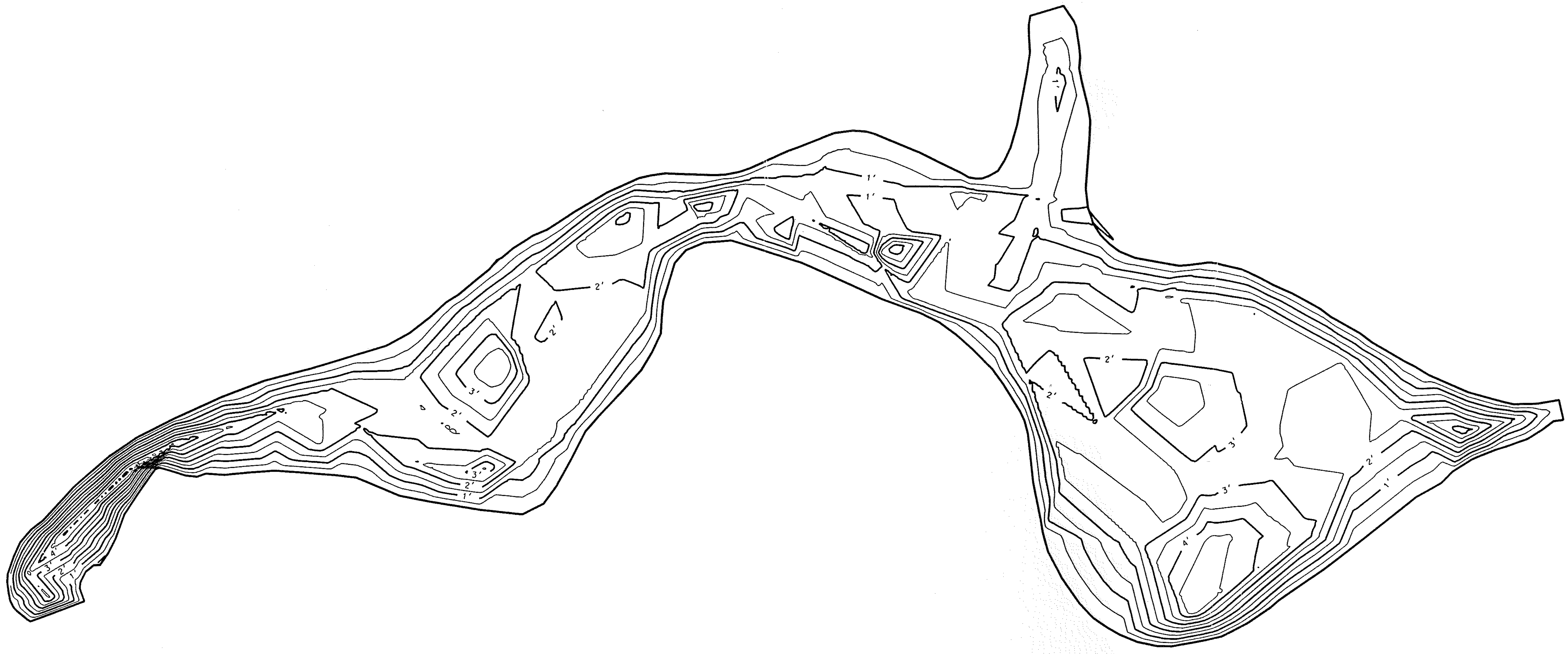
Sediment thickness was measured throughout the main lagoon. Probes were used to determine the top of sediment and the bottom of soft sediment. Contour maps were developed for the bottom of the lagoon based on these measurements. Figure 4-1 shows the sediment thickness for the lagoon.

The volume of sediment measured totaled 39,429 cubic yards. The sediment thickness ranged from one foot to over 4 feet on the east and west ends of the lagoon. The volume of sediment totals over 70 million pounds by dry weight. The amount of BOD in the sediment is about 28,000 pounds and the amount of phosphorus is about 40,000 pounds.

4.3 Sediment Impact on Water Quality

The large amounts of BOD and phosphorus in the sediment contribute to the poor water quality in the lagoon. The BOD will remove oxygen from the lower water levels and the sediment will release phosphorus into the water which contributes to the excessive algae growth. Long term improvements to the water quality of the lagoon must address the impact the sediment has on the water quality of the lagoon.

The sediment thickness also contributes to the loss of water depth and volume over time. Potential lagoon improvements may include artificial aeration and this process works better with greater depth. A shallow lagoon will be more difficult to aerate and limit the effectiveness of aeration equipment.



Wednesday, July 26, 2000 03:47:27 PM
Page: 1
Grid Volume Report

Original Surface: BOTTOM OF SEDIMENT
Design Surface: TOP OF SEDIMENT

Cut (cu yd)	Fill (cu yd)	Net (cu yd)
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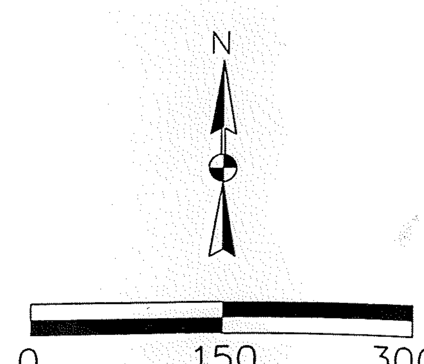


FIGURE 4-1
SEDIMENT THICKNESS
Bay Beach Wildlife Sanctuary
Brown County, Wisconsin

4/9/2001	Foth & Van Dyke consultants – engineers – scientists	0g03f1.3d

5 Watershed Analysis

A watershed is an area of land in which water drains to a common point, such as a stream, lake or wetland. A lake reflects its watershed because the watershed contributes both the water required to maintain a lake, and the majority of pollutants which enter the lake. Therefore, effective lake management programs must include watershed management practices, as lake problems generally cannot be solved without controlling the sources in the watershed. Managing the watershed to control nonpoint pollutants such as nutrients, soil, and other substances which originate over a relatively broad area is essential to protecting water quality. Water running over the land picks up these materials and transports them to the lake, either directly in runoff or through a tributary stream, drainage system, or groundwater. Water running off a lawn or driveway during a heavy rain is an example of nonpoint source runoff. Land uses such as agriculture, construction, and roadways contribute higher nonpoint pollutant loads than other land uses such as forests. Controlling nonpoint pollution sources can usually be achieved by implementing best management practices. However, it must be noted that nonpoint pollution sources are harder to identify, isolate, and control than point sources (distinct sources such as a wastewater treatment plant or an industrial facility). Controlling the water that runs from the land's surface into a lake is important as lakes receive water directly from drainage of the surrounding land (watershed) and precipitation.

The watershed, or land area, which drains ***into*** the Bay Beach Wildlife Sanctuary lagoons was delineated by Foth & Van Dyke, and is illustrated on Figure 5-1. The map was prepared using LandSat imagery which is made available by the WDNR. Figure 5-2 summarizes the land use classifications within the watershed and the total acreage and percentage of land use each comprises.

The watershed is relatively small, and is situated within the City of Green Bay, Brown County, Wisconsin. The watershed of the Wildlife Sanctuary comprises a land area of 283 acres while the lagoon itself comprises approximately 42 acres of surface water. Therefore, the watershed to lake area ratio is about 7:1. The larger the ratio, the more the watershed will have an impact on the lake through nutrient, pesticide, and soil runoff. A watershed to lake area ratio of 7:1 is small and the watershed has a proportionately small impact on the lagoons.

Not all areas of the watershed are equal nutrient or pollutant contributors. By identifying those critical areas that contribute excessive amounts of soil and nutrients to the lake, the most effective controls can be developed. For example, agricultural runoff carrying animal wastes, soil, and nutrients can be a critical pollutant contributor. Urban runoff from lawns, gardens, streets, and rooftops may be significant sources of sediment, oils and greases, nutrients, and heavy metals to lakes. Construction and forestry activities can provide significant quantities of sediments, especially during rainstorms. In small watersheds, lakeside activities may be more critical pollutant contributors. However, in large watersheds, the contributions from urban, forestry, and agricultural areas are generally more significant than those from lakeshore homes.

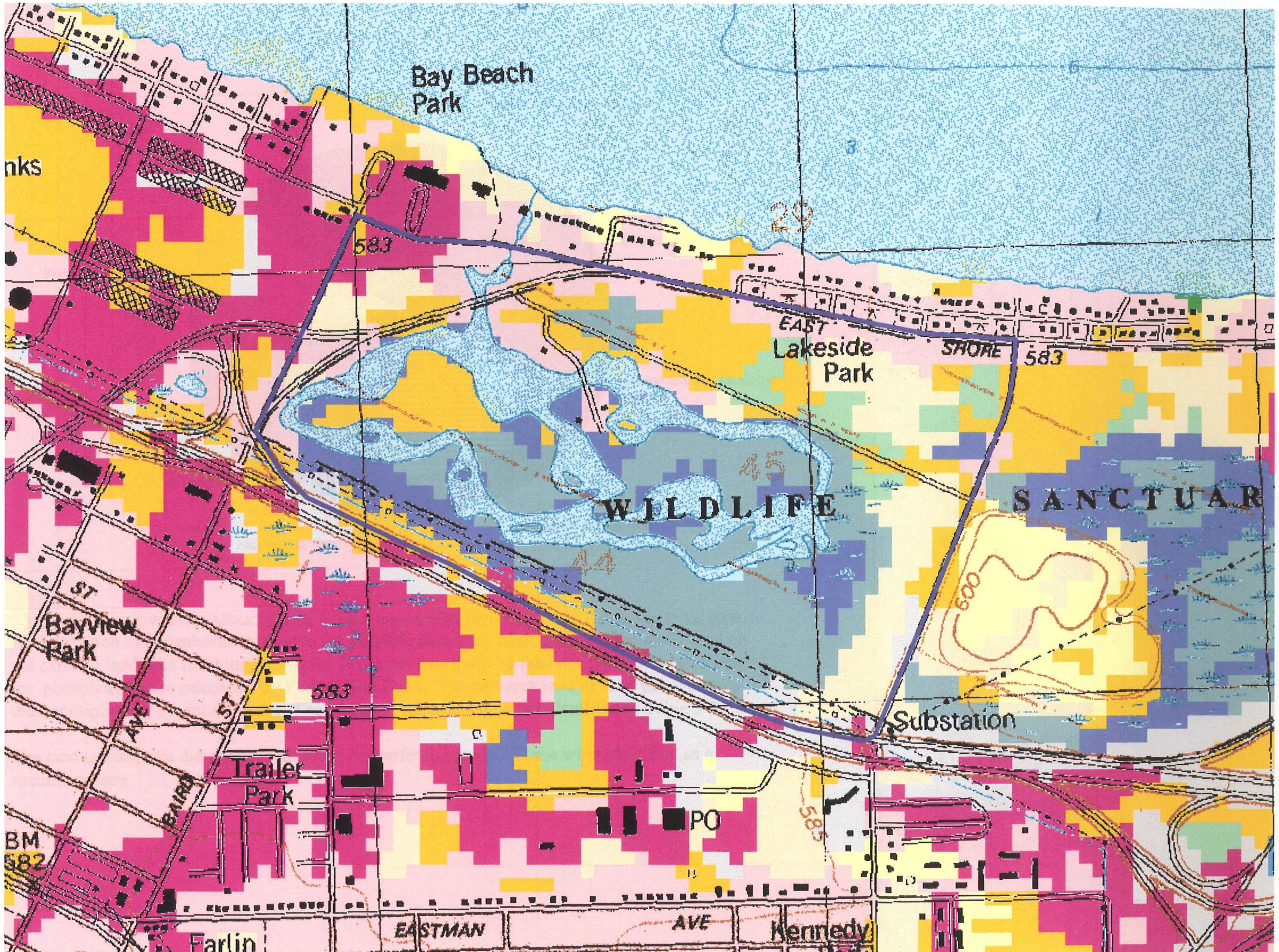


FIGURE 5-1
LAND COVER & U.S.G.S. QUADRANGLE
Bay Beach Wildlife Sanctuary
Brown County, Wisconsin

State of Wisconsin

- High Intensity Developed
- Low Intensity Developed
- Primary Row Crops
- Forage Crops
- Grassland
- Mixed/Other Coniferous
- Mixed/Other Broad-leaved Deciduous
- Surface Water
- Emergent/Wet Meadow
- Lowland Shrub
- Forested: Broad-leaved Deciduous
- Forested: Coniferous
- Forested: Mixed Deciduous/Coniferous
- Barren
- Bay Beach Wildlife Sanctuary Watershed

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5-minute topographic quadrangle - School Hill (1973). Classification derived from LANDSAT Thematic Mapper (TM) satellite imagery from 1991, 1992, and 1993. The classification has been smoothed to a one acre minimum mapping unit (4 contiguous pixels) from the original 30-meter pixel size. Wetlands less than one acre and open water pixels were not smoothed. Classification was done by the Wisconsin DNR - Geo Services Section. Watershed delineation done by Foth and Van Dyke, 2000.

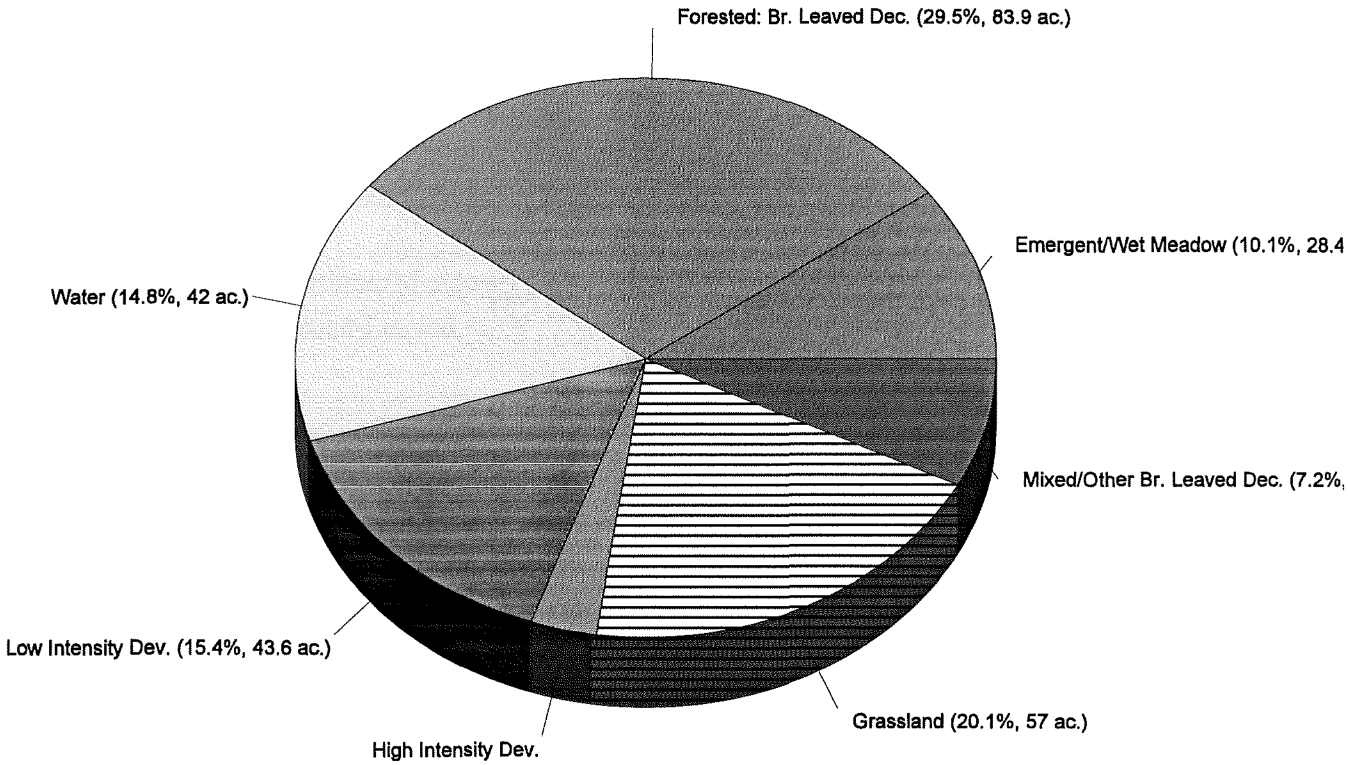
0 200 400 600 800 1000 Feet

Foth & Van Dyke
consultants · engineers · scientists

N

M:\00g003\apr\baybeach2.apr December 6, 2000 Drawn by: KPK1 Checked by: ARM

Figure 5-2
Generalized Existing Land Cover
Bay Beach Wildlife Sanctuary Lagoon Watershed



Source: WDNR LANSAT satellite imagery mapper from 1991, 1992, 1993; Foth & Van Dyke, 2000.

An estimation of phosphorus loading to the Wildlife Sanctuary lagoons was calculated based on the existing land uses illustrated in Figure 5-1. Unit area loads by land use type in lbs/acre/year for phosphorus were calculated by Foth & Van Dyke. The unit area load by land use type was then multiplied by the total acreage The results of the calculation are identified in Table 5-1.

The land use impacts did not account for the waterfowl impacts. These were identified as a specific source.

Table 5-1
Existing Phosphorus Loading (in lbs/yr)
Bay Beach Wildlife Sanctuary

Land Use Class	Acreage	Phosphorus (lbs/yr)	% of Total Phosphorus
High Intensity Development	8.0	4.0	49%
Low Intensity Development	43.6	2.2	28%
Grassland	57.0	0.6	7%
Mixed/Other Broad Leaved Deciduous	20.5	0.2	2%
Emergent Wetland/Meadow	28.4	0.3	4%
Forested: Broad Leaved Deciduous	83.9	0.8	10%
Total	241.4	8.1	100%

Area Loads by Land Use (lbs/acre/year); Foth & Van Dyke, 2000.

The table identifies the estimated existing phosphorus loadings for the Bay Beach Wildlife Sanctuary lagoons watershed. The high intensity development has the greatest land use impact on the lagoon's water quality based on the amount of phosphorus it contributes to the lagoon. As identified in the table, high intensity development uses contribute approximately 49% of the phosphorus associated with land use practices which enters the lake on an annual basis. There are some common "Best Management Practices" (BMP's) which can be used to help protect the lake's water quality from pollutants/nutrients. These BMP's are available from WDNR or local county extension offices.

6 Waterfowl Impacts

The resident and migratory waterfowl at the Bay Beach Wildlife Sanctuary have a significant impact on water quality as large populations of giant Canada geese and mallard ducks use the wildlife refuge. Approximately 67% of the waterfowl use the main lagoon based on observations of the staff at the Bay Beach Wildlife Sanctuary.

Appendix B contains the waterfowl counts and the impact from waterfowl defecation. In summary, waterfowl defecation totals 58 tons dry fecal matter each year. Included in that total is over 1,700 lbs phosphorus per year. When this value for phosphorus is compared to the estimated 8.1 lbs phosphorus per year from the watershed, it is clear that waterfowl are the largest contributor (over 99.5%) on the phosphorus loading to the lagoon.

Waterfowl defecation also contributes organic compounds and nitrogen compounds to the lagoon. These compounds are degraded by microorganisms consuming oxygen in the process. The oxygen demand especially consumes most if not all the oxygen in the lower depths of the lagoons.

BAY BEACH WILDLIFE SANCTUARY
SAMPLING DATA

Date	BOD mg/l	Total P mg/l	Chlorophyll a ug/l	Secchi Depth Feet
May 03, 2000	14.9	0.489	NA	2
June 27, 2000	14.4	1.01	42	0.5
July 25, 2000	29.2	1.11	NA	0.5
August 22, 2000	20	1.31	148.9	0.5
February 12, 2001	4.9	0.838	11	2

TROPHIC STATUS DETERMINATION FOR
BAY BEACH LAGOON

	SECCHI DEPTH		
	FEET	METERS	WTSI
May 03, 2000	2	0.61	67
June 27, 2000	0.5	0.15	87
July 25, 2000	0.5	0.15	87
August 22, 2000	0.5	0.15	87
February 12, 2001	2	0.61	67

	Chlorophyll a	
CHL a (ug/l)	ug/l	WTSI
May 03, 2000		
June 27, 2000	42	63
July 25, 2000		
August 22, 2000	148.9	73
February 12, 2001	12	54

	Total Phosphorus	
	ug/l	WTSI
May 03, 2000	489	76
June 27, 2000	1010	82
July 25, 2000	1110	82
August 22, 2000	1310	84
February 12, 2001	838	80

BAY BEACH WILDFLIFE SANCTUARY

Summary of Temperature/Dissolved Oxygen Measurements

	Temp. C	DO mg/l	Depth Ft.
May 02, 2000	15.53	11.04	0
	15.49	11.18	1
	15.39	11.25	2
	15.26	11.19	3
	13.85	5.69	4
	12.46	2.05	5
	10.33	0.81	6
	8.93	0.44	7
	7.89	0.28	8
	7.62	0.23	9
	7.3	0.18	10

	Temp. C	DO mg/l	Depth Ft.
August 22, 2000	22.2	16.90	0
	21.8	15.22	1
	21.1	9.30	2
	21	3.35	3
	20.6	0.90	4
	20.3	0.45	5
	19.9	0.28	6
	18.7	0.20	7
	18	0.18	8
	15	0.46	9
	14.8	0.45	10

	Temp. C	DO mg/l	Depth Ft.
June 27, 2000	22.31	8.63	0
	22.32	8.23	1
	22.21	7.72	2
	22.14	5.35	3
	21.91	1.88	4
	21.16	0.36	5
	20.18	0.21	6
	17.83	0.15	7
	15.97	0.20	8
	13.33	0.14	9
	12.57	0.11	10
	11.76	0.10	11

	Temp. C	DO mg/l	Depth Ft.
February 12, 2001	0.7	1.24	0
	0.7	0.92	1
	1.9	0.62	2
	3.1	0.45	3
	3.9	0.34	4
	4.2	0.25	5
	4.4	0.18	6
	4.4	0.14	7
	4.6	0.10	8

	Temp. C	DO mg/l	Depth Ft.
July 2, 2000	23.4	19.17	0
	22.4	18.99	1
	22.5	18.95	2
	20.6	2.36	3
	21.1	0.67	4
	19.7	0.70	5
	19.4	0.51	6
	18.7	0.60	7
	17.5	0.59	8
	15.5	0.80	9
	14.1	0.80	10

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Environmental Science Section (608) 224-6277 DNR LAB ID 113133790
Inorganic chemistry

Id: Point/Well/..: 001 Field #: SAMPLE PT1 Route: LM40
Collection Date: 05/02/00 Time: 08:45 County: 05 (Brown)
End Date: 05/02/00 Time: 09:15
From: 1616 E SHORE DR GREEN BAY - SAMPLE POINT #1
Description: SURFACE WATER
To: DENNIS LORITZ
DNR Source: Surface Water
GREEN BAY
Account number: LM006 Collected by: JANSSEN/PAYNE

Date Received: 05/03/00 Labslip #: IK024126 Reported: 06/07/00

BOD 5 DAY (SM 5210B)	14.9	MG/L
CALCIUM, DIG, ICP (SW846 6010B)	35.	MG/L
CHLOROPHYLL A, UNCORRECTED, LAB FILT (SM 10200H)	**	UG/L #1
COLOR, TRUE, PT-CO (SM 2120B)	50.	SU
CONDUCTIVITY (AT 25 DEG C) (SM 2510B)	562.	UMHOS/CM #2
PH, LAB (SM 4500B)	*8.81	SU #2
ALKALINITY (AS CACO3) (SM 2320B)	*142.	MG/L #2
DIG 730.1, ICP, LIQ, EXCEPT AS/SE/AG (SW846 3010A)	DIG MET	
IRON, DIG, ICP (SW846 6010B)	0.04	MG/L
detected between 0.02 (LOD) and 0.08 (LOQ) MG/L		
MAGNESIUM, DIG, ICP (SW846 6010B)	17.	MG/L
MANGANESE, DIG, ICP (SW846 6010B)	27.	UG/L
AMMONIA (AS N), DISS (LACHAT 10-107-06-1-J)	0.105	MG/L
NITRATE+NITRITE (AS N),DISS (LACHAT 10-107-04-1-J)	ND (LOD=0.01 MG/L)	
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	0.489	MG/L
DISS REACTIVE PHOSPHORUS AS P (ORTHO-P)(SM 4500PE)	**	MG/L #3
POTASSIUM, DIG, ICP (SW846 6010B)	5.2	MG/L
SODIUM, DIG, ICP (SW846 6010B)	55.	MG/L
SULFATE (EPA 375.2)	105.	MG/L
TOTAL DISSOLVED SOLIDS, 180 C (SM 2540C)	366.	MG/L
TOTAL SOLIDS (SM 2540B)	396.	MG/L
TOTAL VOLATILE SOLIDS (SM 2540E)	88.	MG/L
SUSPENDED SOLIDS (SM 2540D)	8.	MG/L
TURBIDITY, NON-SDWA COMPLIANCE (SM 2130B)	10.5	NTU
TEMPERATURE ON RECEIPT	ICED	C
ICP TEST	ICP	

--- Footnotes ---
Remark #1: LABORATORY ACCIDENT, NO TEST DONE
Remark #2: HOLDING TIME EXCEEDED FOR ALK AND pH BY 1 DAY
Remark #3: NO BOTTLE RECEIVED, NO TEST DONE

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Inorganic chemistry (#2 of 4 on 09/06/00, unseen)

Id: Point/Well/..: 001 Field #: SAMPLE PT1 Route: FH40
Collection Date: 06/27/00 Time: 09:00 County: 05 (Brown)
End Date: 06/27/00 Time: 09:30
From: 1660 EAST SHORE DR GREEN BAY - SAMPLE POINT #1
Description: SURFACE WATER
To: SCOTT SZYMANSKI
DNR Source: Surface Water
GREEN BAY
Account number: LM006 Collected by: JANSSEN/PAYNE
Waterbody/permit/..: 117800
L, P, L, 6, 8, 1
Date Received: 06/28/00 Labslip #: IK031950 Reported: 09/05/00

BOD 5 DAY (SM 5210B)	14.4	MG/L	
CHLOROPHYLL A, UNCORRECTED, LAB FILT (SM 10200H)	42.	UG/L	
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	*1.01	MG/L	#1

--- Footnotes ---
Remark #1: HOLDING TIME EXCEEDED BY 14 DAYS

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Environmental Science Section (608) 224-6277 DNR LAB ID 113133790
Inorganic chemistry (#15 of 16 on 09/20/00, unseen)

Id: Point/Well/..: 001 Field #: SAMPLE PT1 Route: FH40
Collection Date: 07/25/00 Time: 10:30 County: 05 (Brown)
End Date: 07/25/00 Time: 11:00
From: 1660 EAST SHORE DR GREEN BAY - SAMPLE POINT #1
To: SCOTT SZYMANSKI
DNR Source: Surface Water
GREEN BAY
Account number: LM007 Collected by: PAYNE
Waterbody/permit/..: 117800
L, P, L, 6, 8, 1
Date Received: 07/26/00 Labslip #: IL002235 Reported: 09/19/00

BOD 5 DAY (SM 5210B)	*29.2	MG/L	#1
CHLOROPHYLL A, UNCORRECTED, LAB FILT (SM 10200H)	**	UG/L	#2
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	*1.11	MG/L	#3
TEMPERATURE ON RECEIPT	ICED	C	

--- Footnotes ---
Remark #1: POSSIBLE TOXICITY
Remark #2: INSUFFICIENT SAMPLE, NO TEST DONE
Remark #3: HOLDING TIME EXCEEDED BY 16 DAYS

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Inorganic chemistry (#17 of 26 on 10/11/00, unseen)

Id: Point/Well/..:   Field #: SAMPLEPT 1 Route: FH40
Collection Date: 08/22/00 Time: 09:30 County: 00 (Unknown)
End Date: 08/22/00 Time: 10:30
From: 1660 E SHORE DR GREEN BAY WI 54302 - #1 SURFACE WATER
To: SCOTT SZYMANSKI
DNR   Source: Surface Water
GREEN BAY
Account number: LM007   Collected by:
Waterbody/permit/..: 117800
L, P, L, 6, 8, 1
Date Received: 08/23/00   Labslip #: IL004826   Reported: 10/10/00

BOD 5 DAY (SM 5210B)	<24.0	MG/L
CHLOROPHYLL A, UNCORRECTED, LAB FILT (SM 10200H)	*148.9	UG/L #1
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	1.31	MG/L
TEMPERATURE ON RECEIPT	ICED	C

--- Footnotes ---
Remark #1: DUPLICATE EXCEEDS LIMIT, RESULT AVG OF 139.8 & 158

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Inorganic chemistry (#10 of 16 on 04/05/01, unseen)

Id: Point/Well/..: 001   Field #: SAMPLE PT1 Route: FH40
Collection Date: 02/12/01 Time: 13:00 County: 05 (Brown)
From: 1660 E SHORE DR, GREEN BAY
Description: FISHING LAGOON, SAMPLE POINT #1, SURFACE WATER
To: SZYMAS
DNR   Source: Surface Water
GREEN BAY
Account number: LM007   Collected by: PAYNE
Waterbody/permit/..: 117800
L, P, L, 6, 8, 1
Date Received: 02/13/01   Labslip #: IL016256   Reported: 04/04/01

BOD 5 DAY (SM 5210B)	*4.9	MG/L #1
CHLOROPHYLL A, UNCORR, TRICHROMATIC (SM 10200H)	*11.	UG/L #2
CHLOROPHYLL A, CORRECTED (SM 10200H)	*6.	UG/L #2
PHEOPHYTIN (SM 10200H)	*8.	UG/L #2
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	0.838	MG/L
TEMPERATURE ON RECEIPT-ICED	ICED	C

--- Footnotes ---
Remark #1: HOLDING TIME EXCEEDED BY 6 DAYS
Remark #2: HOLDING TIME EXCEEDED BY 8 DAYS

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Inorganic chemistry

Id: Point/Well/..: Field #: SS1 Route: FH40
Collection Date: 06/26/00 Time: 10:00 County: 05 (Brown)
From: 1660 EAST SHORE DR
Description: SEDIMENT
To: SCOTT SZYMANSKI
DNR
GREEN BAY
Source: Sediment
Account number: LM006 Collected by: JANSSEN

Date Received: 06/29/00 Labslip #: IK032076 Reported: 09/19/00

BOD 5 DAY, DRY WT (SM 5210B)	*377	MG/KG #1
BULK DENSITY (GARRISON 1997)	0.950	GDRY/CCWET #2
PERCENT SOLIDS (SM 2540G)	40.2	% #2
PERCENT VOLATILE SOLIDS (SM 2540G)	**	% #2
TOTAL PHOSPHORUS, DRY WT (USGS I-6600-85)	404	MG/KG
PERCENT VOLATILE SOLIDS (SM 2540G)	2.9	%
PERCENT SOLIDS (SM 2540G)	53.2	%
TEMPERATURE ON RECEIPT	ICED	C

--- Footnotes ---
Remark #1: SLIDING BOD, 3GM=549PPM, 5GM=319PPM, 10GM=262PPM
Remark #2: % VOL SOLIDS NOT NEEDED

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Inorganic chemistry

Id: Point/Well/..:   Field #: SS2   Route: FH40
Collection Date: 06/26/00 Time: 10:15 County: 05 (Brown)
From: 1660 EAST SHORE DR
Description: SEDIMENT
To: SCOTT SZYMANSKI
DNR   Source: Sediment
GREEN BAY
Account number: LM006   Collected by: JANSSEN

Date Received: 06/29/00   Labslip #: IK032077   Reported: 09/19/00

BOD 5 DAY, DRY WT (SM 5210B)	*418	MG/KG #1
BULK DENSITY (GARRISON 1997)	0.630	GDRY/CCWET #2
PERCENT SOLIDS (SM 2540G)	54.7	% #2
PERCENT VOLATILE SOLIDS (SM 2540G)	**	% #2
TOTAL PHOSPHORUS, DRY WT (USGS I-6600-85)	734.	MG/KG
PERCENT VOLATILE SOLIDS (SM 2540G)	5.3	%
PERCENT SOLIDS (SM 2540G)	42.1	%
TEMPERATURE ON RECEIPT	ICED	C

--- Footnotes ---
Remark #1: SLIDING BOD, 3GM=629PPM, 5GM=383PPM, 10GM=241PPM
Remark #2: % VOL SOLIDS NOT NEEDED

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Inorganic chemistry

Id: Point/Well/..: Field #: SS4 Route: FH40
Collection Date: 06/26/00 Time: 10:45 County: 05 (Brown)
From: 1660 EAST SHORE DR
Description: SEDIMENT
To: SCOTT SZYMANSKI
DNR
GREEN BAY
Source: Sediment
Account number: LM006
Collected by: JANSSEN

Date Received: 06/29/00 Labslip #: IK032079 Reported: 09/19/00

BOD 5 DAY, DRY WT (SM 5210B)	*346	MG/KG #1
BULK DENSITY (GARRISON 1997)	0.610	GDRY/CCWET #2
PERCENT SOLIDS (SM 2540G)	52.9	% #2
PERCENT VOLATILE SOLIDS (SM 2540G)	**	% #2
TOTAL PHOSPHORUS, DRY WT (USGS I-6600-85)	378.	MG/KG
PERCENT VOLATILE SOLIDS (SM 2540G)	4.4	%
PERCENT SOLIDS (SM 2540G)	49.4	%
TEMPERATURE ON RECEIPT	ICED	C

--- Footnotes ---
Remark #1: SLIDING BOD, 3GM=538PPM, 5GM=310PPM, 10GM=189PPM
Remark #2: % VOL SOLIDS NOT NEEDED

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Inorganic chemistry

Id: Point/Well/..: Field #: SS3 Route: FH40
Collection Date: 06/26/00 Time: 10:30 County: 05 (Brown)
From: 1660 EAST SHORE DR
Description: SEDIMENT
To: SCOTT SZYMANSKI
DNR
GREEN BAY
Source: Sediment
Account number: LM006 Collected by: JANSSEN

Date Received: 06/29/00 Labslip #: IK032078 Reported: 09/19/00

BOD 5 DAY, DRY WT (SM 5210B)	*361	MG/KG #1
BULK DENSITY (GARRISON 1997)	0.620	GDRY/CCWET #2
PERCENT SOLIDS (SM 2540G)	56.3	% #2
PERCENT VOLATILE SOLIDS (SM 2540G)	**	% #2
TOTAL PHOSPHORUS, DRY WT (USGS I-6600-85)	640.	MG/KG
PERCENT VOLATILE SOLIDS (SM 2540G)	5.2	%
PERCENT SOLIDS (SM 2540G)	42.7	%
TEMPERATURE ON RECEIPT	ICED	C

--- Footnotes ---
Remark #1: SLIDING BOD, 3GM=548PPM, 5GM=327PPM, 10GM=207PPM
Remark #2: % VOL SOLIDS NOT NEEDED

Bay Beach Wildlife Sanctuary – Waterfowl Flock

Waterfowl Flock – Historical Perspective

A brief historical perspective at this point is necessary to establish the framework for the Sanctuary's program over the years culminating in the water quality problems that exist today.

The Bay Beach Wildlife Sanctuary was founded in 1935 by a Chester Cole, a local biology teacher , who was concerned with increasing scarcity of waterfowl, breeding grounds, natural food and resting sites. He proposed developing refuge that would encourage waterfowl, rather than the proposed golf course on a 200 acre parcel at the present location. He enlisted the support of Aldo Leopold in the refuge design. A small hand dug pond was enlarged to over 50 acres of lagoons by the National Youth Administration and Work Projects Administration using a narrow gauge railroad, hand-dump cars and a drag-line.

In 1938, Louis Barkhausen gave the Sanctuary six Canada geese from his private refuge on the west shore of Green Bay with another 3 geese a year later. The Secretary of Agriculture granted a permit to capture sick or wounded waterfowl for the purpose of rehabilitation and release. Many of the birds did recover and remained at the Sanctuary decoying in additional birds during migration. Families begin the popular and traditional waterfowl feeding program with the dispensing of shelled corn.

The water surface was about 30% of the entire refuge. The average depth was six feet. Areas around the ponds were raised two feet by the dredging materials to form natural shaped islands, which were later planted with trees and shrubs.

Since the city could provide more effectively for the long-term management and supervision of the Sanctuary it was taken over by the Green Bay Park and Recreation Department in 1941. (Reference Sanctuary Master Plan Phase I, 1980) In 1982 the Department of Natural Resources, Wisconsin Administrative Code officially listed the Bay Beach Wildlife Sanctuary as a game refuge. (Reference section NR 1.01 Wis. Adm. Code)

In the 1970's artificial nesting platforms or ganderlanders were installed along the lagoon shorelines in an attempt to increase the goose population at the Sanctuary and lower bay. Staff and students from the University of Wisconsin Green Bay fabricated the structures, conducted the "goose training to use" process, monitored the occupancy and nest success and finally removed the platforms as the population became too successful.

In 1980 a goose population explosion occurred at the Sanctuary and nationally, with exponential growth. Our population increased from 250 geese in 1960 to 825 geese in 1980. (Reference – Goose Task Force – report September 21, 2000 page 10).

Sanctuary Waterfowl Population

As part of our Lake Planning Grant a detailed review of the Bay Beach Wildlife Sanctuary's waterfowl flock was conducted. This review included past and present numbers by species and the desired future population goal.

Geese and ducks were counted monthly to compare with previous years and to establish a baseline of data to compare against the water analysis data. Close monitoring of the flock by Sanctuary staff and volunteers determined the "goose use days" on the refuge. Counts were done in a systematic and consistent manner. Two counters (Ty Baumann and Mark Payne) completed all of the counts and enlisted the assistance of volunteers as the in-field recorders. Counts were completed only at the refuge and taken when bird numbers were at the daily peak. (e.g. Time of day counts varied depending on changing feeding forays off the refuge and etc.) The count forms developed for this project and field counts are included in appended materials.

Field counts show a low number of 407 geese and 550 ducks in May to the peak counts of 7,094 geese in October and 4,217 ducks in December respectively. Once again, the behavior and movements of waterfowl continue to be both complex and intriguing. This was verified through: irregular counts in August when only 222 geese were counted on site and the duck count was 3,121 birds; and in January 2001 when the goose count dropped to 481 birds, while the duck population remained very high at 3,950. These large count fluctuations are due to the majority of the goose flock being observed off of the refuge, loafing on exposed mud flats a few thousand yards northeast of the Sanctuary in August and due to freeze up of the surrounding Bay area concentrating the ducks at the Sanctuary lagoon open water areas in December. (Appended – Monthly waterfowl counts from May - February 2000).

To better understand the dynamics of our Sanctuary population, impact on water quality and management options, William Wheeler, Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, presented his Research Report , "Giant Canada Geese in Brown County Wisconsin" through slides and written abstract. This report helped us appreciate population movements and the durability of the Canada goose as a species. For example, "A total of 5,262 geese were marked with U.S. Fish & Wildlife Service leg bands and 797 of these birds were also neck collared with plastic neck-collars during the years 1965-1990". Collared geese were monitored by: field volunteers, recaptured in the July banding process and in hunter kill band returns. Recaptured birds..."at Bay Beach in July occurs from molting subadults from 21 states and provinces (unpublished Wheeler)". Longevity and nesting fidelity of geese at the Sanctuary also proved to be very interesting with the long term reproductive impact being significant! "Six local females were known to be alive over 13 years after banding. Three of these geese lived to be at least 16 years old of which one was recaptured with broods 13 times at Bay Beach and one 14 times". With the average goose clutch size being 5-6 eggs and low young mortality, the potential population increase is 288 goslings from them alone, (3 adult females X 13 years X 6 per clutch = 288 goslings), this is compounded when two years later each female can again raise her own respective young. "Nearly 2,000 geese were moved from Green Bay to reduce overpopulation in the city". The study further showed that the adult geese are very sedentary, spending most of their time and lives here at the Sanctuary . "...or until

January or February weather moves them south". The release of this research report in April of 2000 made the timing perfect to augment our own Sanctuary water quality evaluation project.

Waterfowl Impacts

This portion of the Phase I Water Quality Evaluation Project studied and provides a quantitative value of the impact waterfowl have on the lagoon. Sanctuary staff assisted by our consulting firm Foth & Van Dyke collected water samples, had them analyzed and include those findings in the body of this final report. For example, it was determined that multiplying the number of waterfowl times the waterfowl use days times their collective annual waste contribution yielded over 45 tons by dry weight of nutrients. That translates into nine truck loads being deposited directly into the water, on the ice to be later added to the water or on the surrounding land areas to wash into the lagoon. Waterfowl waste has been determined to be the major contributing source of lagoon nutrients.

During the course of this study it became obvious that the waterfowl population was impacting more than just the water quality. The flock was also having a significant impact on the surrounding physical refuge as a resource and the public who visit the refuge, travel near the refuge and live in and or around Green Bay.

In order to address some of these related issues it was determined by the Sanctuary staff that a waterfowl task force (Goose Task Force – GTF for short) would be a real asset to involve the community in this project and help plot the course for long range management and issue resolution. Our staff had provided some input to the "Wisconsin Urban Waterfowl Task Force" and reviewed their final report and recommendations as it pertained to our similar problem. Although, the ongoing contribution of this task force is outside the scope of our Lake Planning Grants, the results to-date will have a very direct and immediate affect on the adoption and implementation of recommendations provided through our Lake Planning Grant Phase II – Evaluation of Water Quality Improvements.

Certainly one of the most significant contributions of the Goose Task Force has been to raise the awareness level in the community about the Sanctuary, its water quality problem, the waterfowl flock as the major contributor and the need for public support at all levels to find and implement solutions.

The GTF is comprised of 16 members representing a cross section of our community that have a key interest or stake in the outcome. Individuals represent the scientific community, DNR, U.S. Fish & Wildlife Service, Chamber of Commerce, farmers, homemakers, engineers, politicians, Friends of the Sanctuary, City of Green Bay Park Director, Lake Association, Brown County Land Conservation and staff. Additional individuals with interest and/or expertise have been included to provide for a balanced and informative presentation of information. For example, members of the RPAWS organization (Rehabilitation At The Wildlife Sanctuary) inquired about the animal rights and needs issues and professionals from agencies were brought in to present talks, present slides, give handouts and answer questions. Examples: Ricky Lien, DNR Urban Wildlife Specialist; Bill Wheeler, DNR Bureau of Integrated Science Services; and

Jane Weiskittel, USDA Wildlife Services all have played an important role and will be integral in the final course of action.

The stated purpose of the GTF is to take a proactive look at the Sanctuary's waterfowl flock and the issues that are associated with a rapidly expanding local waterfowl population. The expectations are that this group will help determine the community or social level of tolerance for the birds; develop a set of recommendations based on their knowledge, experience, and public input gained through a public information sharing meeting; and submit their findings through the Sanctuary Director to the Green Bay Park Committee and City Common Council for final adoption.

The GTF has met monthly since the first meeting September 21, 2000. At that meeting the purpose and scope of their involvement was presented. (Appended - copy of the Power Point presentation). Member response has been very gratifying, they are interacting with individuals within their sphere of influence and bringing this information to the meetings. This group has challenged staff at each meeting to provide deeper layers of information to work through the complex issues at hand. For example the GTF asked, for the December meeting for a clarification of Sanctuary Levels of Operation to provide advantages, disadvantages and what would be required to manage:
1) Waterfowl Feeding Program, 2) Fishing Program, 3) Open Water Areas, 4) Mowed Areas and Vegetation Management and 5) Lagoon Segregation. For the January meeting the request is for staff to provide clear objectives for: 1) education program, 2) recreation program, 3) feeding program and 4) fishing program. From these meetings the GTF will make their recommendations in spring of 2001 on population control and site management.

Publicity on our Lake Planning Grant project has been excellent. The Goose Task Force activities dealing with waterfowl issues has been of particular interest and has generated a great deal of media attention. All of the task force meetings are open to the public. Good media coverage has kept public attention focused on the grants.

Summary

We have suspected for some time that the water quality in the Sanctuary lagoons is not very good and the waterfowl population is the primary contributor. Although extremely popular with families with children as the traditional thing to do in Green Bay, waterfowl feeding and bird numbers could threaten its own existence.

This project has allowed us to examine in depth the problem by collecting the data that substantiates our concerns and offers a plan to correct the problem. This process has further generated community awareness, understanding and appreciation that will be necessary to go the next step leading to action that is biologically feasible and socially acceptable. Volunteers have been recruited to participate in virtually all aspects of the project. Equipment purchased by the Sanctuary, to assist in the grant study, will allow staff and volunteers to continue to monitor the water quality for many years to come and become part of our long term management strategy.

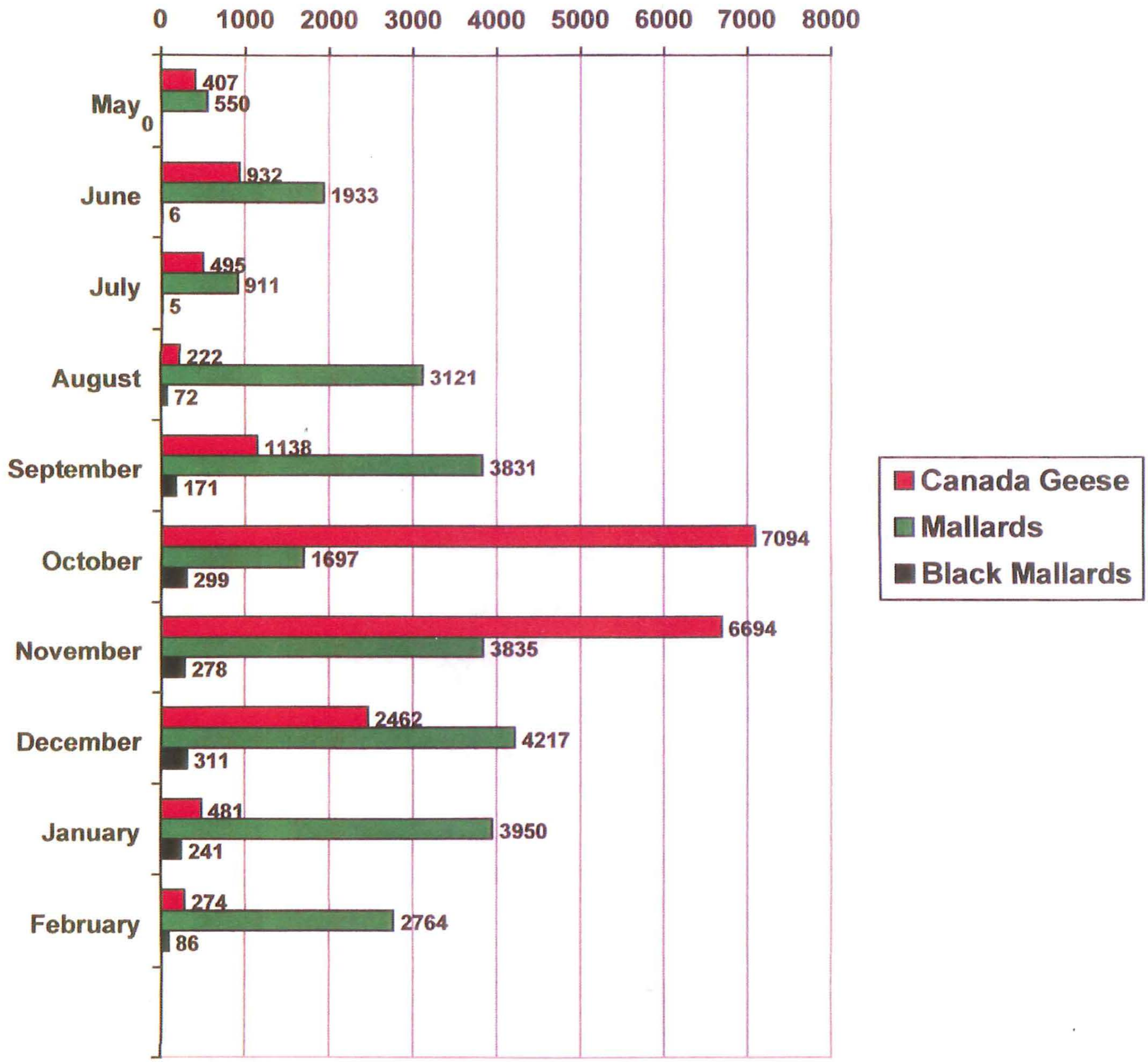
Waterfowl Use Days
Species – Canada Geese
Year 1999 – 2000
Notes:

- Mild winter, little snow = larger number of waterfowl over-wintering at the WLS Refuge, birds forage off the refuge midmorning and late afternoon
- Refuge experiences large fall influx of geese during October
- Hard weather movement anticipated about end of December to early January – migration south of lingering migrants
- Number of geese on & off the refuge per hour are averages as it varies from day to day
- Typical 24 hour detail breakdown = 4 pm – 8 am Fox River = 16 hours
  8 am – 10 am loaf @ WLS = 2 hours
  10 am – 2 pm forage = 4 hours
  2 pm – 4 pm loaf = 2 hours
  @ 4 pm fly to Fox River and start over (in recent years with mild winters flock stayed over night at WLS)
- .Observations made over 30 years by resident Sanctuary Director

Month	Total # of Birds	Hours/Day	# of Birds/Hour On/Off Refuge	Comments
January	~3,400	24	1,900 On all day/night	
		16	1,500 Off all night	roost at Fox River mouth
		8	500 On day	eat & loaf
		3	1,000 off day	forage farm fields
		5	1,000 on day	eat & loaf
February	~3,400	Same as for previous month		
March	~3,700	16	1,000 On all night	end of month # > due to migrat.
		4	3,300 Off day	forage farm fields/manure
		8	300 On all day/night	never leave refuge
		5	3,300 On few hours	loaf then out to forage again
April	~4,000	14	2,500 On all night	numbers show > from migration
		10	1,500 On all day	remainder foraging off refuge
May	296 adults	24	296 On all day/night	numbers show nesting dispersal
	111 goslings	24	111 On all day/night	~300 1 yr olds leave WLS & wander
June	832 adults	24	732 On all day/night	~ 100 adults w/ goslings walk into WLS from Bay islands
	100 goslings	24	100 On all day/night	end of June early July molt
July	495	24	495 On all day/night	goslings now - young of year 1st year birds wandering mix with refuge birds and observed on Bay (500 yards from refuge)
August	222	24	222 On all day/night	large numbers of geese including our refuge birds feeding & loafing on Bay mud flats – not a typical year normally about 1,000+ geese on the refuge
September	1,138	24	338 On all day/night	
		14	1,138 On all night	
		10	800 Off all day	foraging farm fields/loafing Bay

October	7,094	16	7,094 On all night	big autumn migration influx
		4	6,500 On day	loaf after off-refuge foraging
		4	500 On day	never leave refuge
November	6,000	16	6,000 On all night	freeze up mid month, keep
		4	5,700 On day	loaf after off-refuge foraging
		4	300 On day	never leave refuge, graze dead grass/cattails etc.
December	5,800	17	3,500 On all night	swim keep water open
		4	5,800 On day	loaf, feed, sit/sleep on ice
		3	300 On day	never leave refuge

WATERFOWL COUNTS
2000-2001



Bay Beach Wildlife Sanctuary
Goose Population Estimate - 1999 - 2000

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
Jan.	1900	24	45600		
	500	8	4000		
	1000	5	5000		
Total			54600	2275	70525

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
Feb.	1900	24	45600		
	500	8	4000		
	1000	5	5000		
Total			54600	2275	63700

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
March	1000	16	16000		
	300	8	2400		
	3300	5	16500		
Total			34900	1454	45079

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
April	2500	14	35000		
	1500	10	15000		
Total			50000	2083	62500

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
May	296	24	7104		
	111	24	2664	(goslings)	

Total			9768	407	12617

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
June	832	24	19968		
	100	24	2400	(goslings)	
Total			22368	932	27960

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
July	495	24	11880		
Total			11880	495	15345

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
August	222	24	5328		
Total			5328	222	6882

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
Sept.	338	24	8112		
	1138	14	15932		
Total			24044	1002	30055

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
Oct.	7094	16	113504		
	500	8	4000		
	6500	4	26000		
Total			143504	5979	185359

Equivalent Goose-Days

Month	Number	Hrs/day	Goose-hrs	Goose-Days	Per Month
Nov.	6000	16	96000		
	300	8	2400		
	5700	4	22800		
Total			121200	5050	151500

Month	Number	Hrs/day	Goose-hrs	Equivalent Goose-Days	Goose-Days Per Month
Dec.	3500	17	59500		
	5800	4	23200		
	300	7	2100		
Total			84800	3533	109533

Goose-Days per Year = 781,056

BAY BEACH WILDLIFE SANCTUARY

IMPACT OF GOOSE DEFECATION ON MAIN LAGOON

A. 781,056 Goose-days/year

Based on count and estimates from Ty Baumann

B. Approximately 67% of geese use Main Pond

520,730 Goose-days/year on the Main Pond

C. Goose defecation

From 1994 paper by Manny et. al.

32.76	gr/day dry weight fecal matter
2560	gr/wild goose (5.6 lbs/bird)
1.28%	fecal matter per body weight

The fecal matter is composed of by weight as follows:

76.00%	carbon
4.80%	nitrogen
1.50%	phosphorus

Note this same paper cites other studies that found 2% to 4%

D. Convert values to Giant Canada Geese

13	lbs average giant Canada goose
1.28%	fecal matter per body weight
0.166	lbs fecal matter per goose per day

E. Annual Totals of Goose Fecal Matter in Main Pond

86628	lbs fecal matter per year
43	tons dry fecal matter per year

65838	lbs carbon per year
4158	lbs nitrogen per year
1299	lbs phosphorus per year

F. Add Impact from Ducks

The lagoon use by ducks is approximately equal in numbers to geese

Ducks weigh about 1/3 of a goose

Assume that defecation amount per body weight and concentrations are the same

4.3	lbs average duck
1.28%	fecal matter per body weight
0.055	lbs fecal matter per duck per day
28876	lbs fecal matter per year
14	tons dry fecal matter per year
21946	lbs carbon per year
1386	lbs nitrogen per year
433	lbs phosphorus per year

Total All Waterfowl

115504	lbs fecal matter per year
58	tons dry fecal matter per year
87783	lbs carbon per year
5544	lbs nitrogen per year
1733	lbs phosphorus per year

G. Convert to BOD

Laboratory testing done on fecal matter showed

0.145 lbs BOD per lb dry fecal matter

16748 lbs BOD per year.

H. Oxygen Demand

DO for BOD removal =	1.8	lbs/lb BOD
DO for ammonia removal =	4.6	lbs/lb nitrogen
DO for BOD removal =	30147	lbs/yr
DO for ammonia removal =	25503	lbs/yr
Total =	55650	lbs/yr

Maximum month = October with 23.70% of annual demand

Total for maximum month =	13189.1	lbs/month
=	425.453	lbs/day oxygen

Goose Task Force

Bay Beach Wildlife Sanctuary

September 21, 2000

Goose Task Force Members

- Mike Lyson
- Bill Landvatter
- Jay Hamann
- Bud Harris
- Dan Haefs
- Jeff DeGrave
- Ron Antonneau
- Jerry Berg
- Jeanne Agneesens
- Jon Bechle
- Janet Smith
- Bob Cook
- David Nennig
- Tom Bahti
- Frank Roznik
- Ty Baumann

Purpose of Task Force

Why was the group formed?

What are the expectations?

Ground Rules

Looking to solve problem

DNR may need to sign off on possible solution(s)

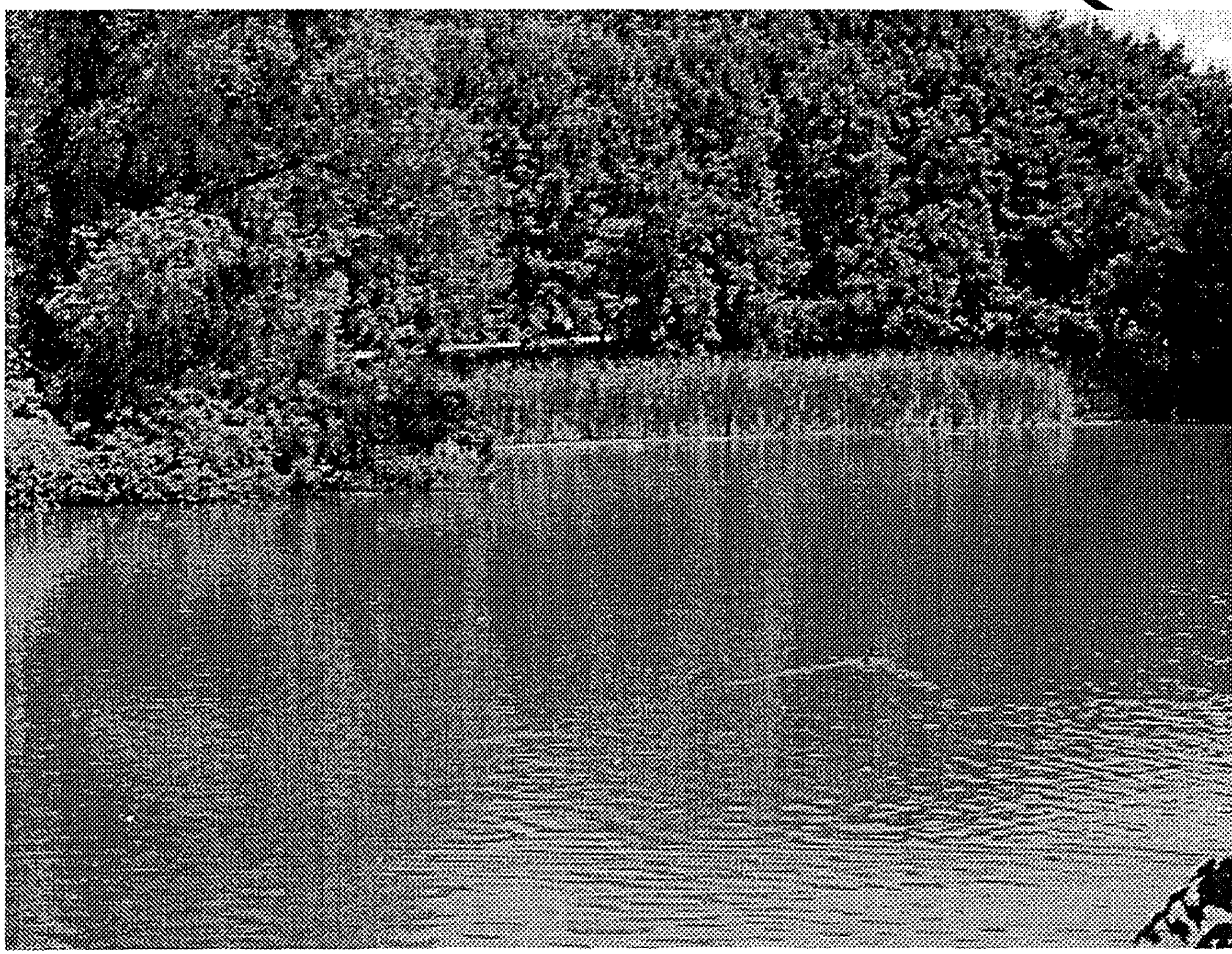
What is GTF's Role?

- Review waterfowl population
- Determine impact on area
- Provide experience and knowledge
- Act as a resource
- Recommend possible solutions

Site Information

Bay
Beach
Wildlife
Sanctuary

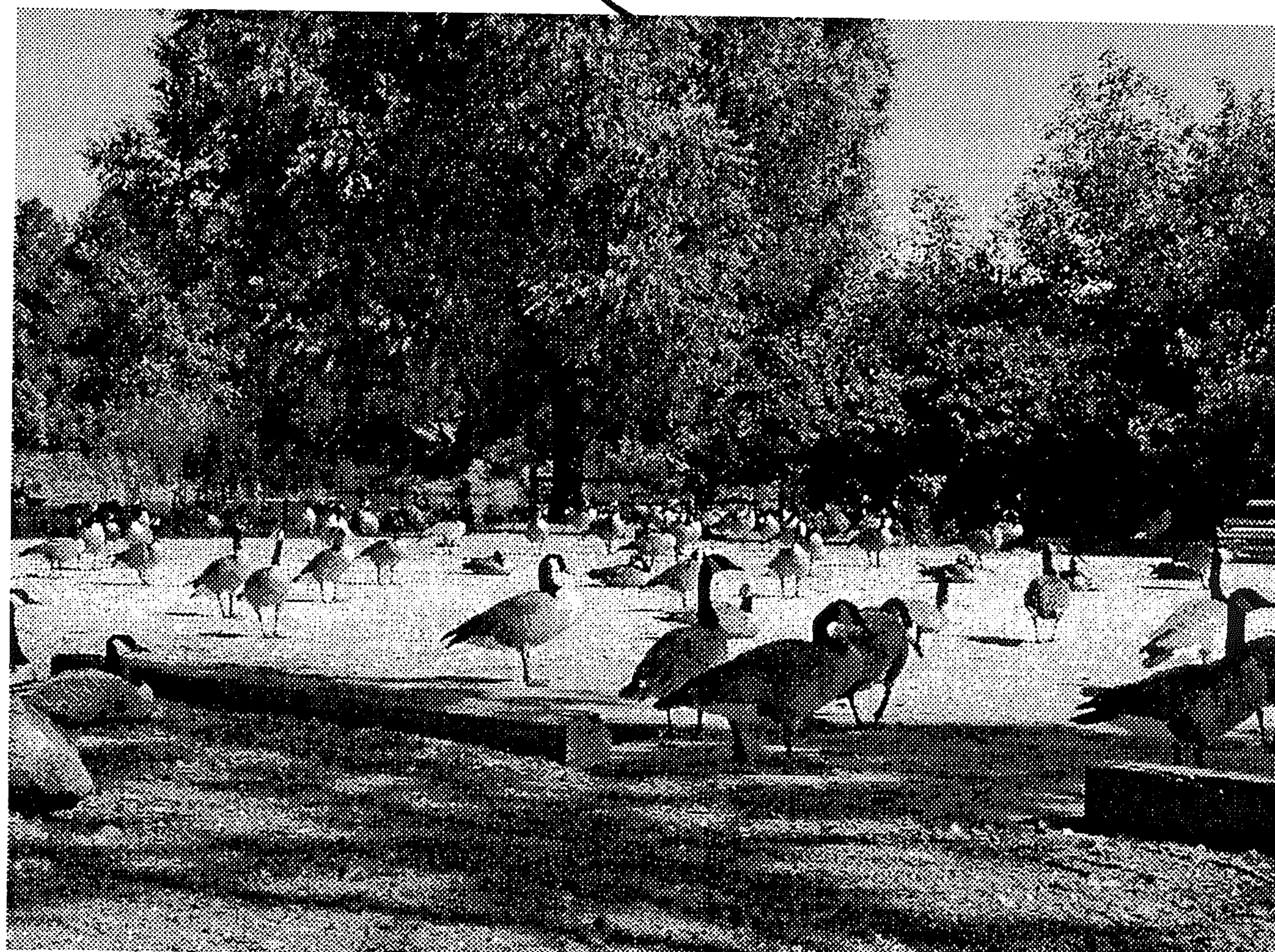
Site Information



Lagoon size

Site Information

Current goose population

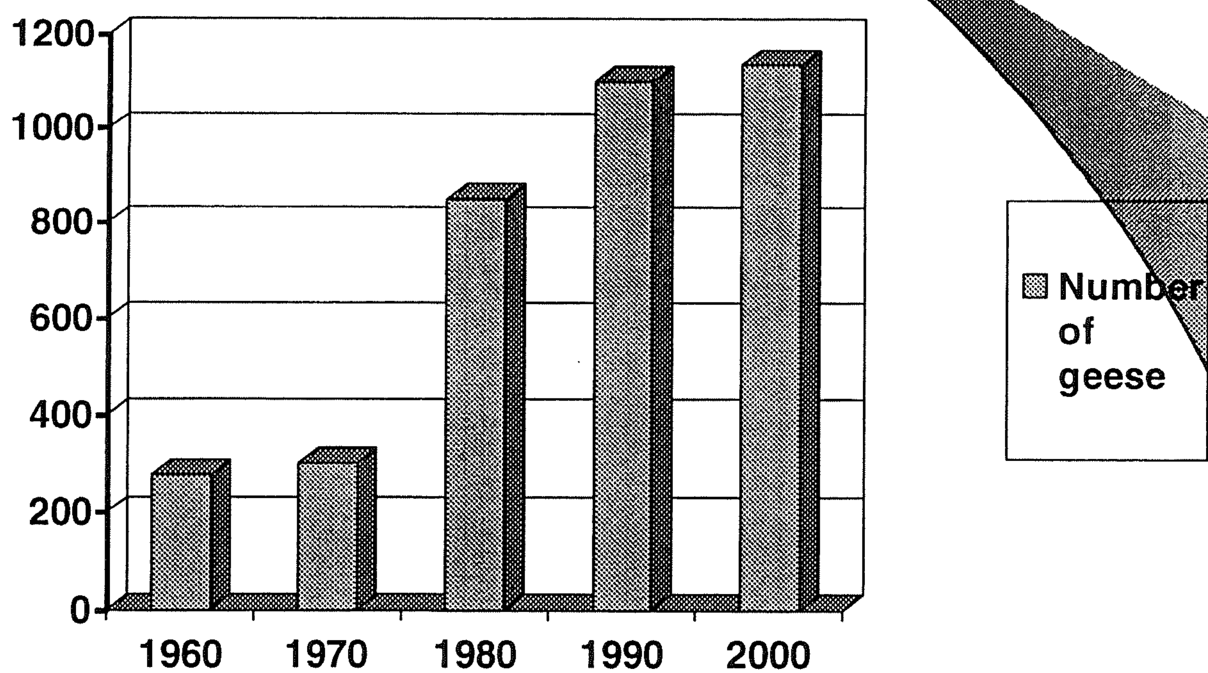


Site Information

- Low goose population until 1980s
- In 1980s, efforts begin to increase population
- Feeding program increases
- Artificial goose platforms created

Site Information

Population explosion



Time of Year: July – September

Site Information

Results:

- Lagoons overloaded with nutrients
- Fish population drastically reduced
- Shore erosion

Site Information

Results:

- Lack of nesting areas
- Geese move off site to nest

Site Specific Challenges

Poor water quality

- High in phosphorous
- Severe year-round algae blooms
- Increased public demand for local fishing opportunities
- Shoreline erosion
- Grass over-grazing
- Bad odor & poor color

What's Next

Think about
possible solutions