WINTER HAVEN
The Chain of Lakes City

2017

Annual Lakes Report

Presented by the Lakes Advisory Committee

CITY OF WINTER HAVEN
Public Works Department
Natural Resources Division

Executive Summary

The residents of Winter Haven have continually recognized the significant role lakes play in the social, economic, and ecologic fabric of the community. This report is presented by the Lakes Advisory Committee which is comprised of members representing a variety of local interests, serving the community by:

- Receiving input on the state of local lakes.
- Advising on the direction of management strategies.
- Communicating that information with the City Commission.

This report strives to achieve that through three main sections:

1.) An introduction
    - Providing a brief background on the ecological processes that drive the health of local waterbodies and the metrics that are applied to assess them.

2.) A presentation and analysis of the data.
    - Serving as a snapshot in time of the current local trends in lake health.

3.) An overview of major management strategies.
    - Outlining the action taken by the City to improve lake health.

There is a strong relationship between water quality and hydrology in the area. Since 2017 had one of the driest dry seasons in recent years, resulting in low lake levels that did not rebound until after Hurricane Irma, there have been some annual average declines in water quality from last year, however the long term trends still provide an optimistic outlook. Another shining insight from this year is that the Southern Chain of Lakes vegetative communities are made up of less than 15% invasive species and we hope to continue to see these low numbers through interagency cooperation.

As a community that identifies so closely with its natural resources, it is important that the City continue to have an advantageous understanding of the function of these systems, the regulations that surround them, and an ability to apply management strategies to secure their health. Many of the lake health challenges we face today, created over generations, will not be overcome with quick fix solutions, but with long term management strategy.

The Natural Resources Division, with the advice of the Lakes Advisory Committee, and in cooperation with various community partners and other City of Winter Haven staff, continuously strive to be good stewards of the community's natural resources. We live in a unique community and I hope you find this report informational and enjoyable. If this peaks your interest, I invite you to reach out to us with any additional questions, thoughts, or comments you may have.

M.J. Carnevale, Natural Resources Manager

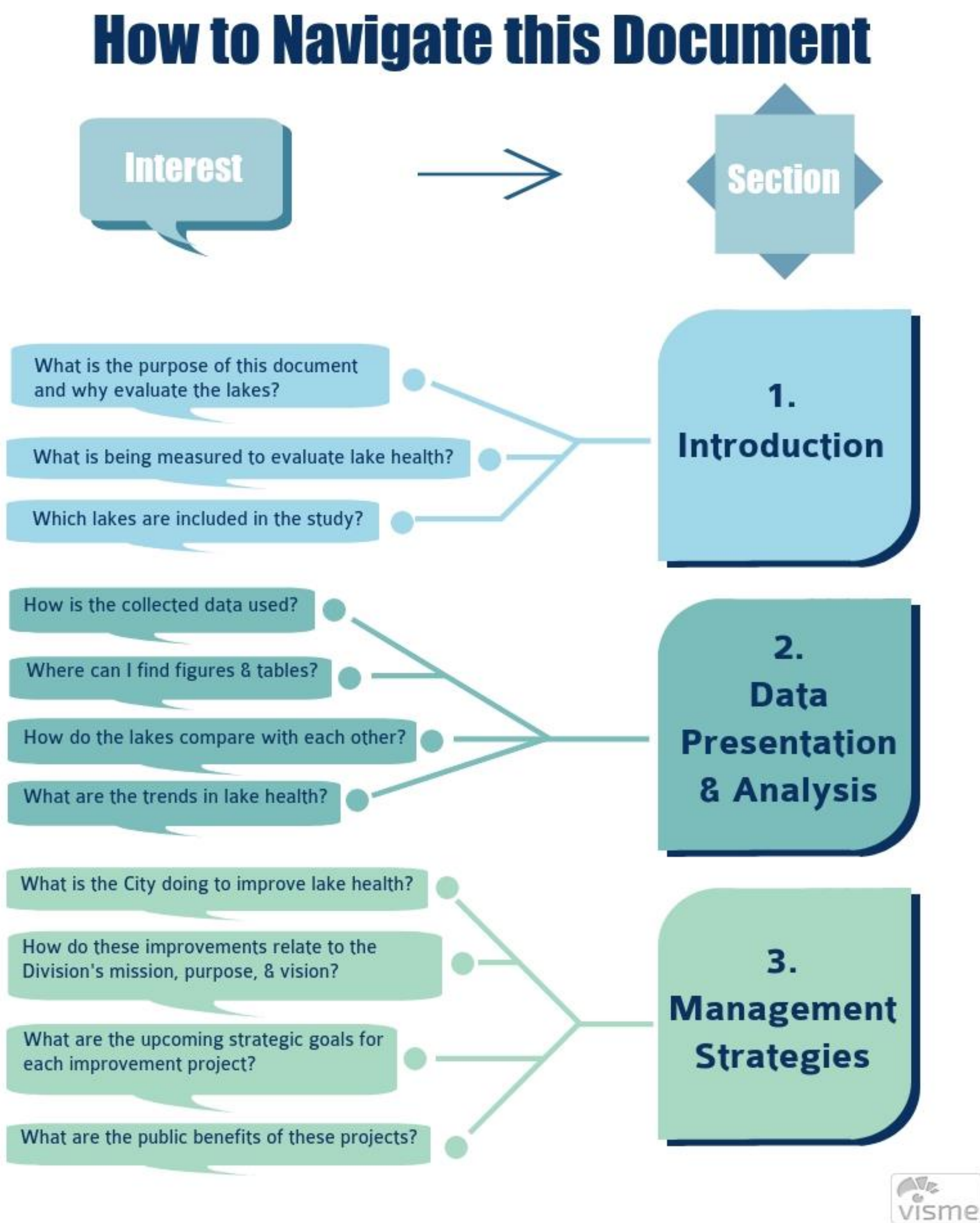

Figure-A How to Navigate the Annual Lakes Report

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1. Introduction

1.1 Purpose

The lakes of the greater Winter Haven area are considered some of its most important assets—ecologically, recreationally, and economically. This report was drafted as part of the City's mission to preserve the wellness of these natural commodities for future use by its citizens. Ultimately, the goal was to incorporate data from various sources and metrics into a comprehensive, annual status report in a format that is technically sound, yet accessible. The selection of lakes studied, while not all-encompassing, are representative of the various lake types found in the Winter Haven Ridge and Polk Uplands geographic regions; including the greater part of the Winter Haven Chain of Lakes as well as several waterbodies independent of the chain. The metrics chosen for this report represent the various facets of limnology (the study of lakes) and help to demonstrate the dynamic nature of lake systems; the interaction between and amongst water chemistry, biology, and hydrology. Finally, this report details the developing management strategies that the City's Natural Resources Division as well as Federal, State and Regional agencies employ to help improve and maintain the health of Winter Haven's lakes.

1.2 Background on the Waterbodies

The 35 lakes included in this study area all possess improved public access and are located within or adjacent to Winter Haven's city limits or share a connection with a lake that is. These lakes were categorized into three groups: the Northern Chain comprised of lakes Conine, Fannie, Haines, Hamilton, Little Hamilton, Middle Hamilton, Rochelle, and Smart; the Southern Chain comprised of lakes Cannon, Eloise, Hartridge, Howard, Idylwild, Jessie, Lulu, May, Mirror, Roy, Shipp, Spring, Summit, and Winterset; and the Interior lakes comprised of lakes Blue, Buckeye, Deer, Elbert, Idyl, Link, Mariam, Mariana, Martha, Maude, Otis, Pansy, and Silver. Lake Henry was not included in this study due to an absence of accessibility which has resulted in a lack of valid water quality data. Winter Haven's lakes are part of the Peace Creek sub-basin of the Peace River watershed. Figure 1-1 details the lakes in the study area as well as the flow pathways through the watershed. The lakes of the Southern Chain are maintained at a roughly equalized level, but collectively sit at a higher elevation than the Northern Chain. A lock structure, operated and maintained by the Lakes Region Lakes Management District, connects

Lake Hartridge to Lake Conine and regulates flow from the Southern Chain to the Northern Chain. Lakes Conine, Haines, Rochelle, and Smart operate at an equalized level and flow downstream to lakes Fannie and Hamilton chain, and ultimately drain via the Peace Creek Drainage Canal—a major outfall on the south side of Lake Hamilton. The Southern Chain primarily drains to the Northern Chain, but can also flow out of a major outfall on the south side of Lake Lulu via the Wahneta Farms Drainage Canal when surface level rises to minimum flood level (132 ft NGVD). Several of the Interior Lakes share connections with Winter Haven's Chain of Lakes via drainage ditches or pipes. However, these flow-ways typically only convey water during periods of higher than average surface level.

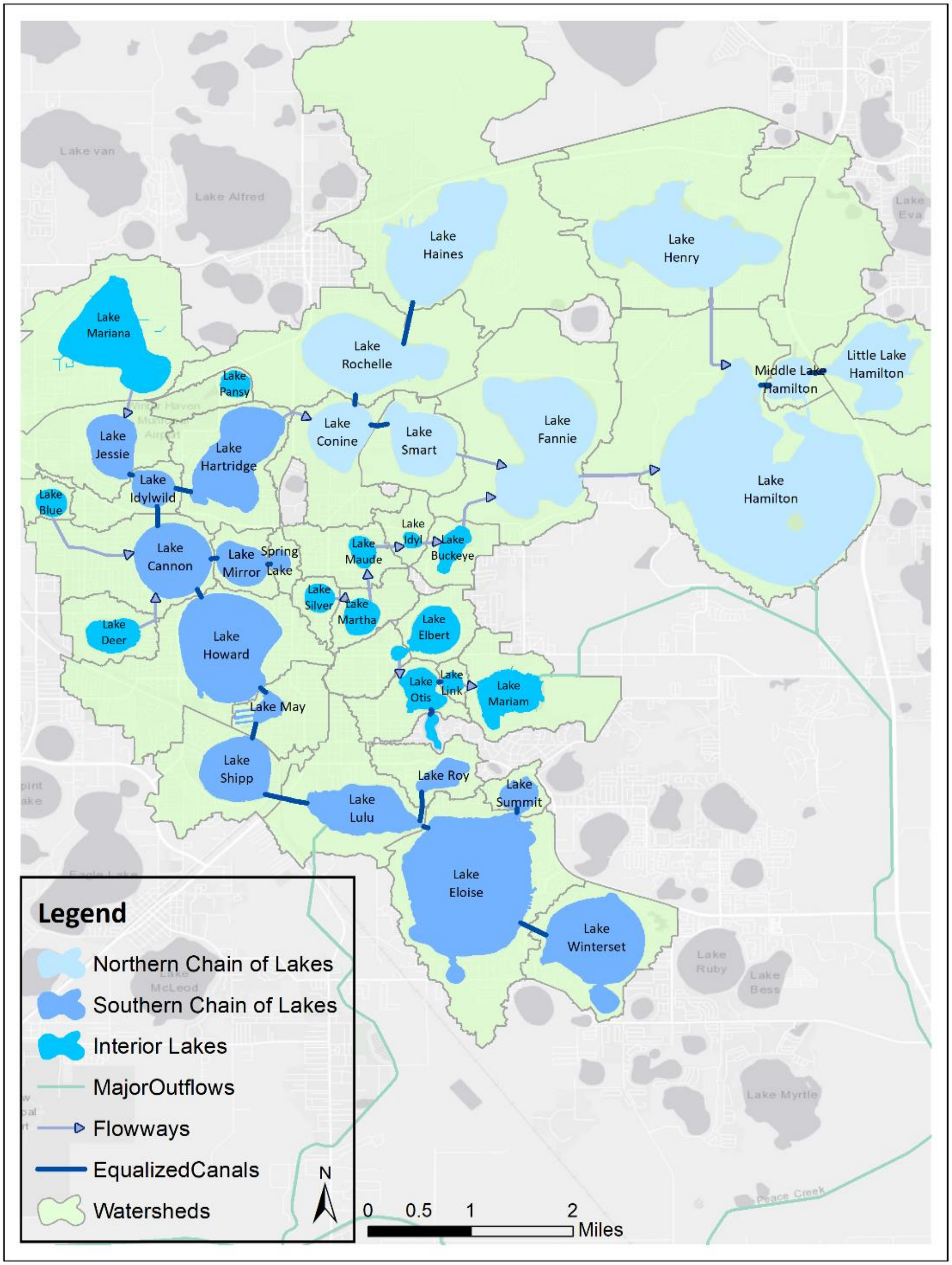

Figure 1-1 Winter Haven lakes with improved public access: major outflows, equalized canals, and flow-ways indicating water pathways through the watershed

1.3 Background on the Metrics

Water Quality/NNC[3]:

In 2010, the US Environmental Protection Agency (EPA) and Florida Department of Environmental Protection (FDEP) mutually agreed to adopt a system to assess the status of Florida's waterbodies under section 303(d) of the Clean Water Act. Numeric Nutrient Criteria (NNC), as part of this system, aims to establish impairment thresholds for chlorophyll a (Chla), total phosphorus (TP) and total nitrogen (TN). Nitrogen and phosphorus are nutrients present in all natural waterbodies and have been determined to have a strong relationship with Chla production—a measurement of phytoplankton (algae) concentration.

Chlorophyll and nutrient concentrations are indicative of the trophic state or productivity of waterbodies where low, medium, and high productivity correspond with oligotrophic, mesotrophic, and eutrophic classifications respectively. The increase in productivity is a process known as eutrophication which occurs naturally as lakes age. However, increasing anthropogenic influence expedites eutrophication and can yield adverse effects including algal blooms, fish kills resulting from hypoxic (low oxygen) conditions, and growth of nuisance macrophytes[1].

Secchi depth, a parameter that represents water clarity, is a measure of the depth of light penetration in the water column. Although Chla concentration has since replaced Secchi depth as a primary trophic state metric, clarity still remains a useful means to determine the amount of suspended solids and phytoplankton in a waterbody. While clarity is often associated with lake cleanliness by the public, this perception can be misleading. The clarity in some lakes is naturally higher or lower than others independent of the health of the waterbody. The water in a shallow lake may be less clear than that of its deeper counterparts due to the effect of wind and waves on the suspension of sediments. While clarity may play a role in the quality of a lake's water, myriad other factors interact dynamically to give rise to the overall health of a waterbody.

Since water chemistry plays a major role in the response of nutrients in a system, thresholds are calculated on a per-lake basis using color (measured in platinum-cobalt units [PCU]) and alkalinity (measured in milligrams per liter calcium carbonate [mg/L $CaCO_3$]). Color is present due to dissolved tannic and humic acids in a waterbody and can be observed as a brown tint or staining. Lake color, as well as clarity, affect light penetration in the water column and subsequently Chla production. Algae requires light to photosynthesize, therefore reduced light penetration in the water column limits phytoplankton growth[2].

Color represents the concentration of dissolved matter while clarity measures the amount of undissolved (particulate) matter in the water column. Despite their shared effects on light penetration, care should be taken not to confuse water color and clarity.

Alkalinity is the measure of the buffering capacity (ability to neutralize an acid) or strength of the dissolved bases in a waterbody. In short, an alkaline waterbody will maintain a relatively stable pH over time. Due to the karst geology (limestone/carbonate rock) underlying Central Florida, most of Winter Haven's lakes are naturally alkaline. The lakes in the study area fall into three categories: Colored lakes (> 40 PCU); Clear, alkaline lakes (≤ 40 PCU and >20 mg/L $CaCO_3$); and Clear, acidic lakes (≤ 40 PCU and ≤ 20 mg/L $CaCO_3$)—derived from measured long-term geometric mean (average) values of color and alkalinity. Long-term refers to a minimum of ten data points over at least three years with at least one data point in each year[8].

Impairment for each NNC parameter is determined when annual geometric mean values exceed the threshold numeric interpretation more than once in a consecutive three year period. Determination of impairment for each parameter follows a specific progression tree beginning with classification of lake type based on color and alkalinity. After lake type is established, Chla impairment it determined. Waterbodies above and below the Chla threshold utilize different nutrient concentrations to determine Chla, TN, and TP impairment. Figure 1-2 depicts a flowchart that explains the numeric criteria interpretation based on thresholds determined by the FDEP[3]. Given these criteria, the City Natural Resources Division (NRD) tracks lake impairment based on Chla, TN, and TP. The FDEP ultimately determines the impairment status of each waterbody, but by monitoring water quality in relation to these thresholds allows the NRD to pre-emptively develop management strategies before lakes are added to any verified lists.

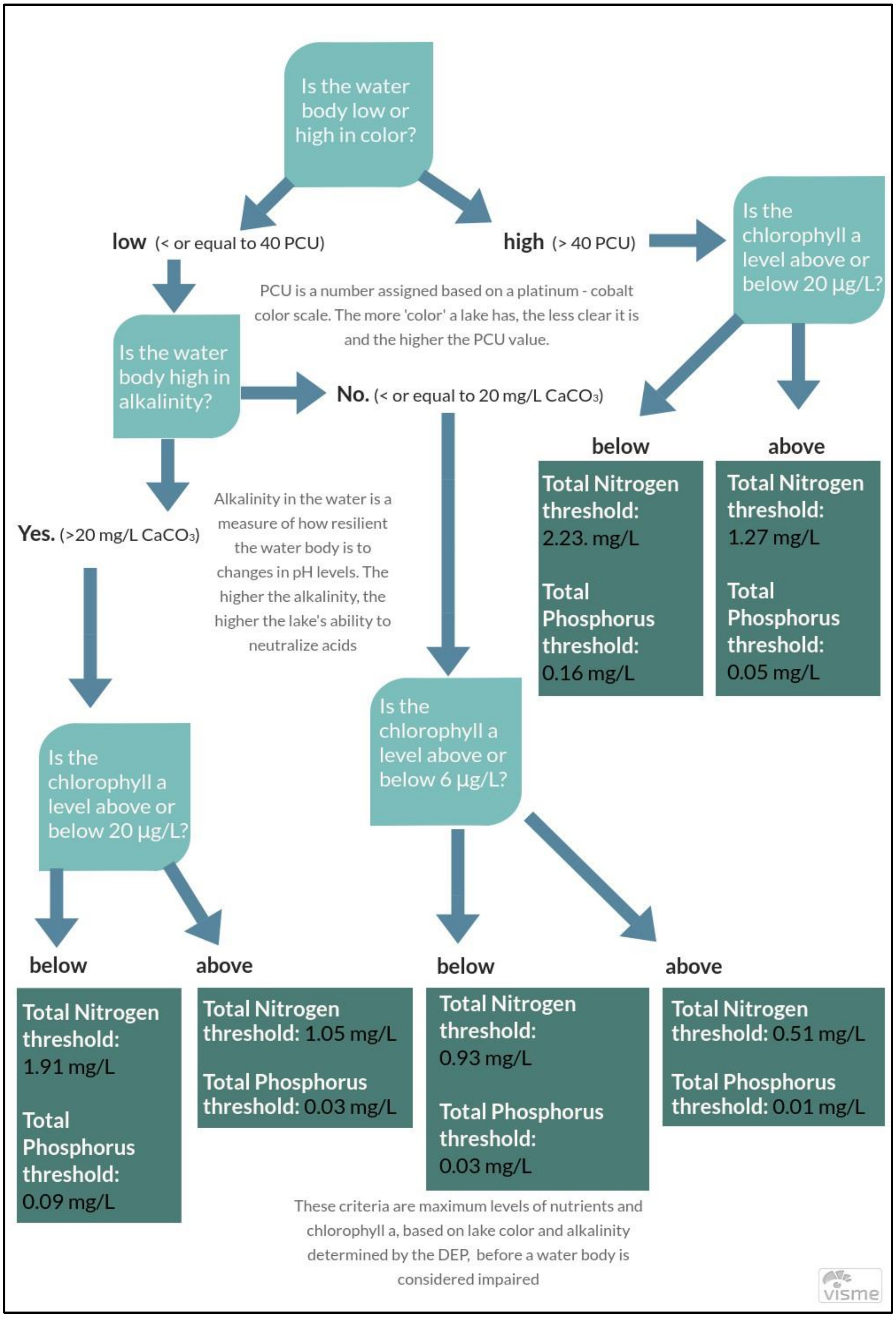

Figure 1-2 FDEP Numeric Nutrient Interpretation flowchart

Total Maximum Daily Load (TMDL)[4]:

A TMDL is the maximum rate of loading of a pollutant that can be assimilated by a waterbody and still meet water quality standards based on the designated use classification of that waterbody. Florida's surface waters are classified into five designated use categories and Winter Haven's lakes fall into Class III: Recreation; propagation, and maintenance of a healthy, well balanced population of fish and wildlife. TMDLs are used to develop restoration goals for impaired waterbodies—as established by the NNC—by setting a baseline for the necessary reduction in nutrient loading in order to meet water quality standards. The TMDL metric is recorded in kilograms per year (kg/yr) of the limiting nutrient(s) for each lake. A limiting nutrient is one that is present in the lowest concentration relative to other nutrients or is the first to be used up by photosynthetic organisms. Once the limiting nutrient is gone, plant and algal growth cannot continue. Most of Winter Haven's lakes are phosphorus limited, but several are co-limited by nitrogen and phosphorus[4]. It is for this reason that management practices are focused on reducing TN or TP inputs to the lakes.

Nutrient loading values can be determined through the modeling of surface water flow, groundwater interaction, nutrient assimilation by plants and algae as well as sediment processes. Point and non-point sources of pollution are taken into consideration in the load modelling. Since all point source (wastewater) inputs to Winter Haven's lakes were removed circa 1992, loading allocations are calculated based on the modelling of non-point (stormwater and internal) sources. Despite the removal of point source inputs, legacy nutrients still remain within lake sediments from historic discharge—contributing to internal pollutant loading. Once TMDLs are established for a waterbody, the FDEP typically develops basin management action plans (BMAPs) to detail protocols for reducing the nutrient load in a waterbody. These protocols range from sediment removal to planting aquatic vegetation in order to drive nutrient concentrations toward acceptable levels. Due to Florida's incredible abundance of waterbodies, the FDEP follows a cyclical schedule to assess the impairment of each major Floridian watershed once every five years. Modelling nutrient inputs to a waterbody is a very extensive and laborious process with priority given to more severe cases of pollution. As a result, TMDLs and BMAPs cannot always be established for each waterbody. Despite these limitations, TMDLs and subsequent BMAPs are especially useful in the development of supplementary lake management strategies when available.

According to the FDEP's 2007 TMDL report, eight lakes of the Southern Chain exceeded impairment thresholds and require reductions in phosphorus loading: Cannon, Howard, Idylwild, Jessie, Lulu, May, Mirror, and Shipp. Table 1-1 provides an example of the TP load reductions required under the TMDL protocol. In addition to the lakes listed above, a TMDL has been established for Lake Deer and the FDEP is currently developing TMDLs for several lakes in the Winter Haven area, including most of the North Chain of Lakes.

Table 0-1 TMDL Values for the Southern Chain of Lakes: existing TP loading and required TP load reductions

Waterbody	Existing TP Load (kg/yr)	TP Reduction Required (kg/yr)	TP % Reduction Required
Cannon	280.2	142.9	51.0
Howard	336.4	143.0	42.5
Idylwild	103.9	64.4	62.0
Jessie	254.1	139.8	55.0
Lulu	167.3	83.7	50.0
May	184.8	87.8	47.5
Mirror	70.6	54.7	77.5
Shipp	241.4	96.6	40.0

Biology:

The metrics in this section are representative of the interactions between aquatic vegetation and the physical characteristics of waterbodies. Vegetative biological volume and abundance quantify macrophyte (plant) growth in a given waterbody. Abundance measures the number of individual organisms while volume is a calculation of the amount of space in the water column taken up by vegetation. The amount of vegetation in lakes affects habitat area, water color, and nutrient concentrations as they cycle through the aquatic system.

Nitrogen (N) and phosphorus (P) go through natural cycles in aquatic environments. Biologically available N and P enter aquatic systems through external loading (surface runoff, stormwater discharge, and atmospheric deposition) as well as internal loading (sediments). Aquatic plants and algae assimilate these dissolved nutrients in their cellular tissue, are consumed or die, and decompose. This detritus settles on lake floors, eventually depositing N and P in the sediment. Certain types of bacteria are able to convert bioavailable nitrogen into atmospheric nitrogen (N_2) which makes up 78% of the air we breathe—essentially removing a portion of it from the aquatic system. Unfortunately, there is no similar process of P removal. The only way to practically extract large amounts of P from lake systems is through the physical removal of nutrients bound in fauna, vegetation, or sediments. This process is exceedingly expensive which is why limiting anthropogenic sources of P loading to the lakes is more fiscally responsible. It should be noted that promoting healthy aquatic plant communities provides a temporary sink for both of these nutrients and limits the available N and P for phytoplankton growth. Aquatic vegetation can act as a buffer against changing nutrient levels and provide a measurable amount of stability to lake systems. Moreover, monitoring vegetation abundance and biovolume can help quantify the amount of nutrients bound in plant tissues and are integral in the calculation of nutrient budgets for each waterbody.

Species richness and evenness are metrics that describe the diversity of aquatic plant communities. A lake with high abundance values may not necessarily be healthy from an ecological standpoint if diversity is low. In order to remain qualified as a Class III waterbody, lakes must promote *healthy* communities of flora and fauna. Competition of invasive macrophytes, such as hydrilla, with native species can minimize spawning and hunting habitat for fauna and choke the water column to the detriment of recreational use. Additionally, a vegetative community with low diversity is more susceptible to decimation by disease, climate change or pests. Limiting competition between native and invasive species is essential in ensuring a robust, healthy aquatic plant community. Herbicide application can be an effective management strategy that requires careful planning to prevent native casualties. An early detection and rapid response system is essential to eliminate invasives before they are able to outcompete native species.

Hydrology:

The observation of the physical characteristics of water and the way it interacts with the land is known as the study of hydrology. Rainfall, groundwater, topography, and lake surface elevation are all part of a dynamic system that affects lake health. For example: rainfall directly contributes to the surface flow in a watershed, increasing lake level as well as recharging groundwater reservoirs. Precipitation can also significantly impact nutrient discharge to the lakes via surface runoff from agricultural, urban, and other land uses. Finally, monitoring rainfall is necessary in the development of a watershed water budget as well as forecasting system responses for potential drought and flooding scenarios.

Groundwater in Florida is stored in different layers: the upper layer known as the surficial aquifer or water table and the deeper, confined Floridan aquifer. Piezometric or potentiometric level represents the static head pressure of the aquifer and can be measured as the height above sea level that water rises inside a well pipe (Figure 1-3). Consequently, surface level in some lakes is impacted significantly by the potentiometric surface level. When the potentiometric surface is low, water drains from lakes more quickly through breaks in the confining layer—causing surface elevation to drop. The opposite occurs when aquifer levels are high: lakes drain more slowly, allowing for rainfall and surface water flow to raise surface level.

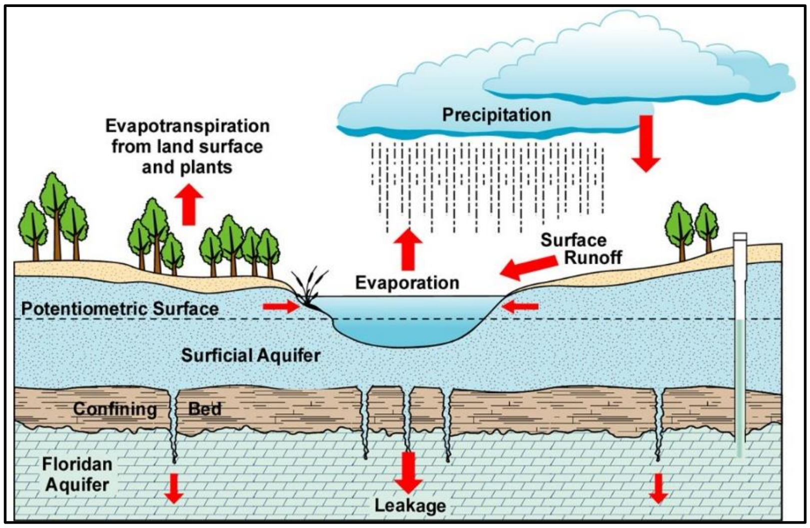

Figure 1-3 Diagram of the water table and the potentiometric surface of a confined aquifer

Topography also significantly impacts how groundwater interacts with each waterbody. Winter Haven's lakes are generally categorized into two groups: ridge lakes and valley lakes[12]. Ridge lakes are characterized by their locations at higher elevation with more pronounced groundwater interaction, steeper slopes, deeper bottoms, modest wetland areas, and narrow littoral zones. Valley lakes, on the other hand, are defined by their lower elevation, large areas of surrounding marshy and forested wetlands, broad littoral zones, and flatter, shallower lake bottoms. Lake elevation determines position relative to the potentiometric surface. Ridge lake surface elevations are typically located above the piezometric level and quickly drain to the aquifer through underlying limestone—this quality denotes these lakes as areas of good aquifer recharge. On the other hand, valley lakes are often known as water storage and treatment areas. These large, shallow lakes drain to the Floridan aquifer much more slowly. This equates to longer retention times which allow for more treatment via the surrounding wetlands.

It has been established that lake surface level is dependent on the combined interactions of rainfall, groundwater level, and topography. Worth noting, is that surface level plays a major role in the cycling of nutrients in lake systems. As surface elevation fluctuates, wetlands and littoral zones can be drained or inundated—affecting the amount of nutrient uptake by aquatic vegetation. Nutrients bound within lake sediments behave differently dependent on surface level as well. A changing volume of water in a reservoir can create gradients that dissolved nitrogen and phosphorus move along to reach equilibrium. This process of nutrients moving back and forth between the water column and sediments is known as nutrient flux. Fluctuations in surface level can transform lake sediments into a massive nutrient sink or source depending on the gradient direction while resuspension of settled bottom sediments can pull additional nutrients out into the water column as more surface area comes in contact with the nutrient gradient. Resuspension of sediments can be exacerbated by lower surface levels as wind and wave action has a greater opportunity to stir up the lake bottom. In conclusion, these cumulative sediment interactions account for what is known as internal nutrient loading in lakes.

2. Data Presentation and Analysis

The following is a presentation of the analytical and inferential viewpoints that take into account short and long-term trends in all applicable lake health metrics. This section focuses on the interpretation of Numeric Nutrient Criteria (NNC), hydrologic, and aquatic vegetation parameters, seeks to elucidate on the results, and presents potential management strategies to improve lake health. In order to make this report possible, the City has utilized data from a variety of sources including: the Polk County Water Atlas[11], the Lakes Region Lakes Management District, the Southwest Florida Water Management District, and the City Natural Resources Division itself.

2.1 Northern Chain of Lakes

The Northern Chain of Lakes mostly consist of large, shallow waterbodies that are typically fringed with dense emergent vegetation and some forested wetland. These lakes are located at the edge of the Winter Haven Ridge—putting them at a lower collective elevation relative to the other lake groups. It can be inferred that the characteristics that designate the majority of the Northern Chain as valley lakes also play a role in their impact to water quality. The following water quality data and trends are explained with references to the hydrologic and biological processes that take place in these waterbodies.

The Northern Chain of Lakes collectively exhibited a moderate decline in water quality from 2016 – 2017 with an overall average 37.5% increase in Chlorophyll a (Chla), 14.4% increase in Total Nitrogen (TN), and a 13.5% increase in Total Phosphorus (TP). Figure 2-1 shows the percentage increase or decrease in the annual average concentration of the NNC parameters for each lake. Of the eight lakes in this group, four displayed a marked increase in all three NNC parameters—Lakes Hamilton, Smart, Little Hamilton, and Middle Hamilton. Lakes Rochelle and Conine showed a moderate increase in Chla and TP while TN remained static. Overall water quality improvement was observed in Lake Fannie during this period while Lake Haines showed a marginal decrease in Chla and TN, albeit with a slight increase in TP. Figure 2-2 illustrates the changes in the annual average Chla, TN, and TP from 2016 – 2017 and how these changes relate to the NNC impairment levels. The TP increases in Lake Haines, Hamilton, and Middle Hamilton were sufficient to push them beyond the impairment threshold while the impairment threshold in Little Hamilton was surpassed for all three NNC parameters.

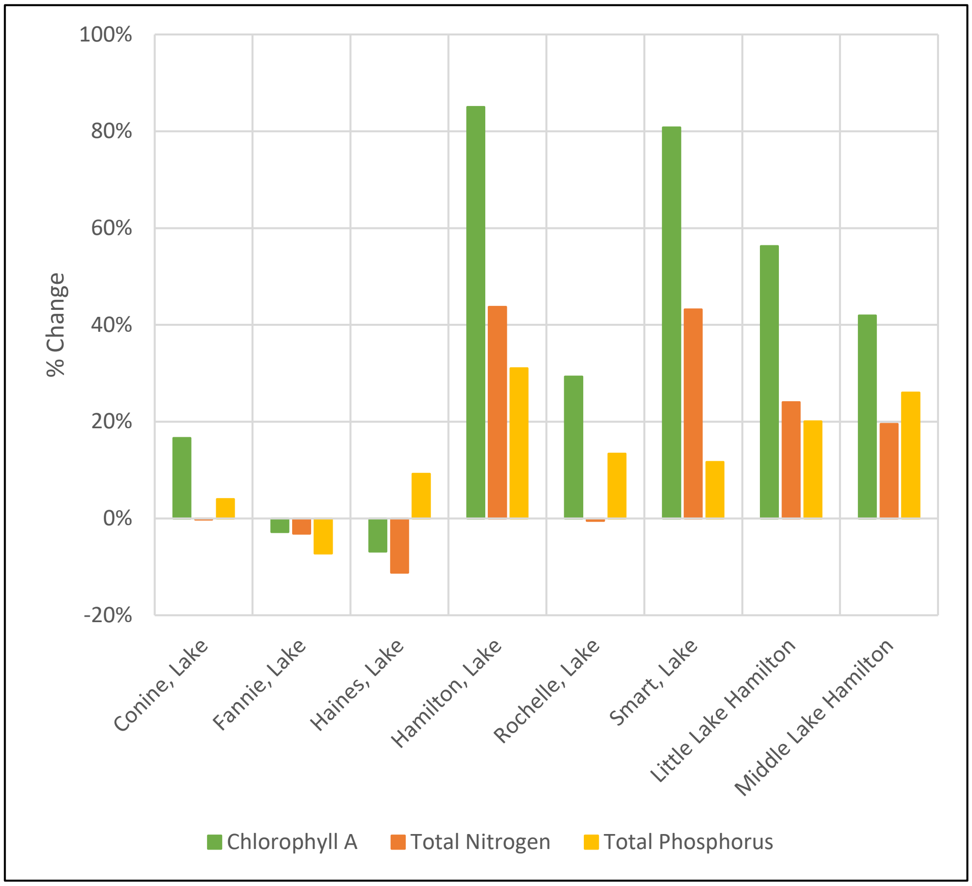

Figure 2-1 Northern Chain of Lakes NNC Percent Change

Despite the short-term decline in water quality in the Northern Chain, the long-term trends remain fairly positive. Figure 2-3 depicts the trends in Chla, TN, TP, and water clarity (Secchi depth) over the last 15 years using a 2-point moving average. Included in this graph is the annual average surface level which provides insight into the hydrologic impacts on water quality. Secchi depth and TP both display positive trends over the period of study, while Chla and TN have only deviated slightly from initial concentrations. The data indicates fairly strong correlation between lake surface level and each water quality metric. Secchi depth fluctuates congruently with lake level—increasing and decreasing with the surface elevation. Whereas Chla and TN display an inverse relationship with the lake stage—increasing in concentration when the level falls. A notable trend is the consistent decrease in TP concentration independent of surface level. This indicates that nutrient reduction methods may be succeeding in reducing TP concentrations over the long-term. Based on this data, the latest decline in water quality from 2016 – 2017 appears to be attributable to a decrease in lake surface elevation in the last year. Even a minimal drop in surface level in these shallow lakes can reduce wetland connectivity and exaggerate sediment suspension—both leading to an increase in nutrient concentrations, an uptick in algal blooms, and a decrease in clarity.

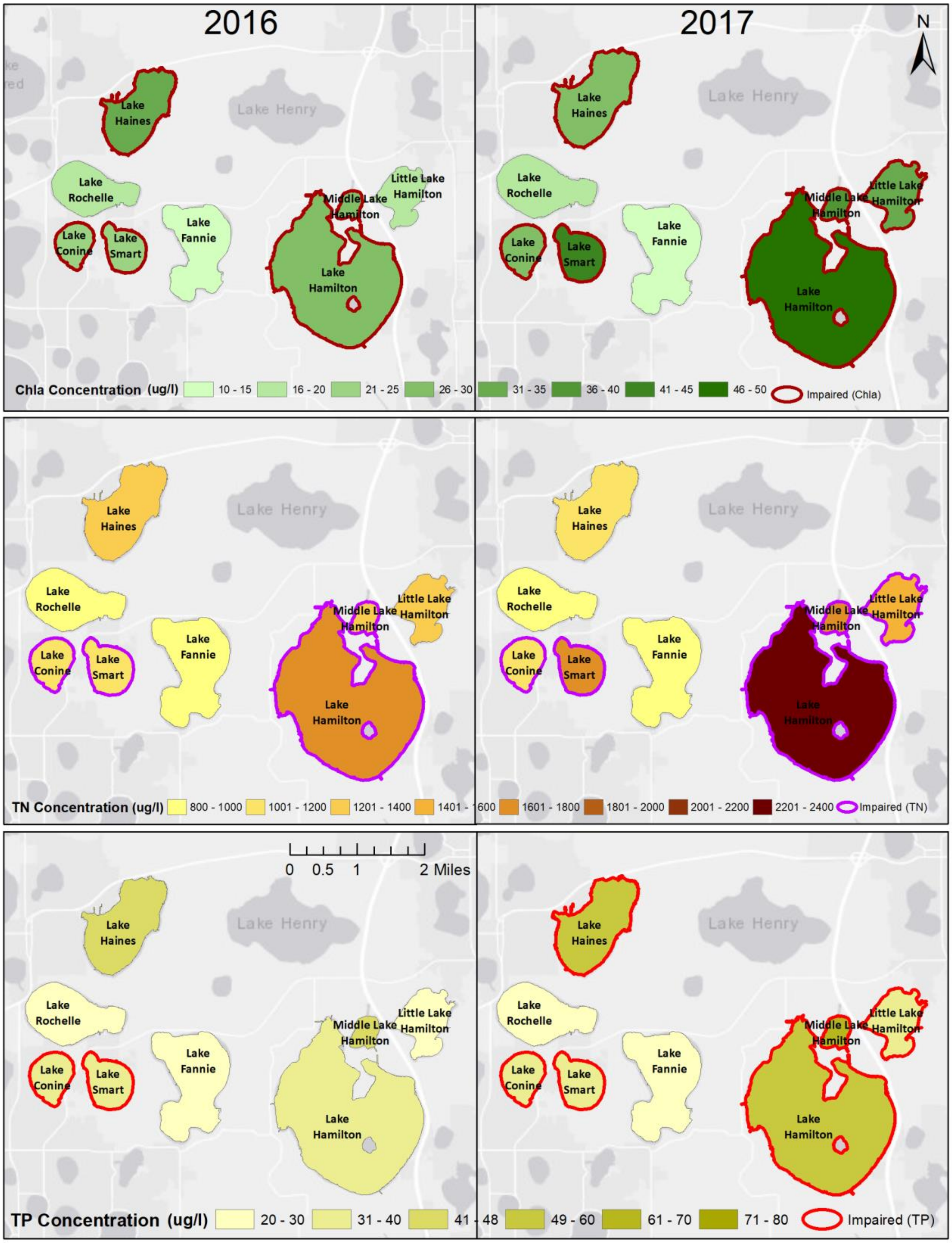

Figure 2-2 Northern Chain of Lakes NNC Impairment Comparison Map

† Impairment indicators in this figure do not represent the official ruling by the FDEP.

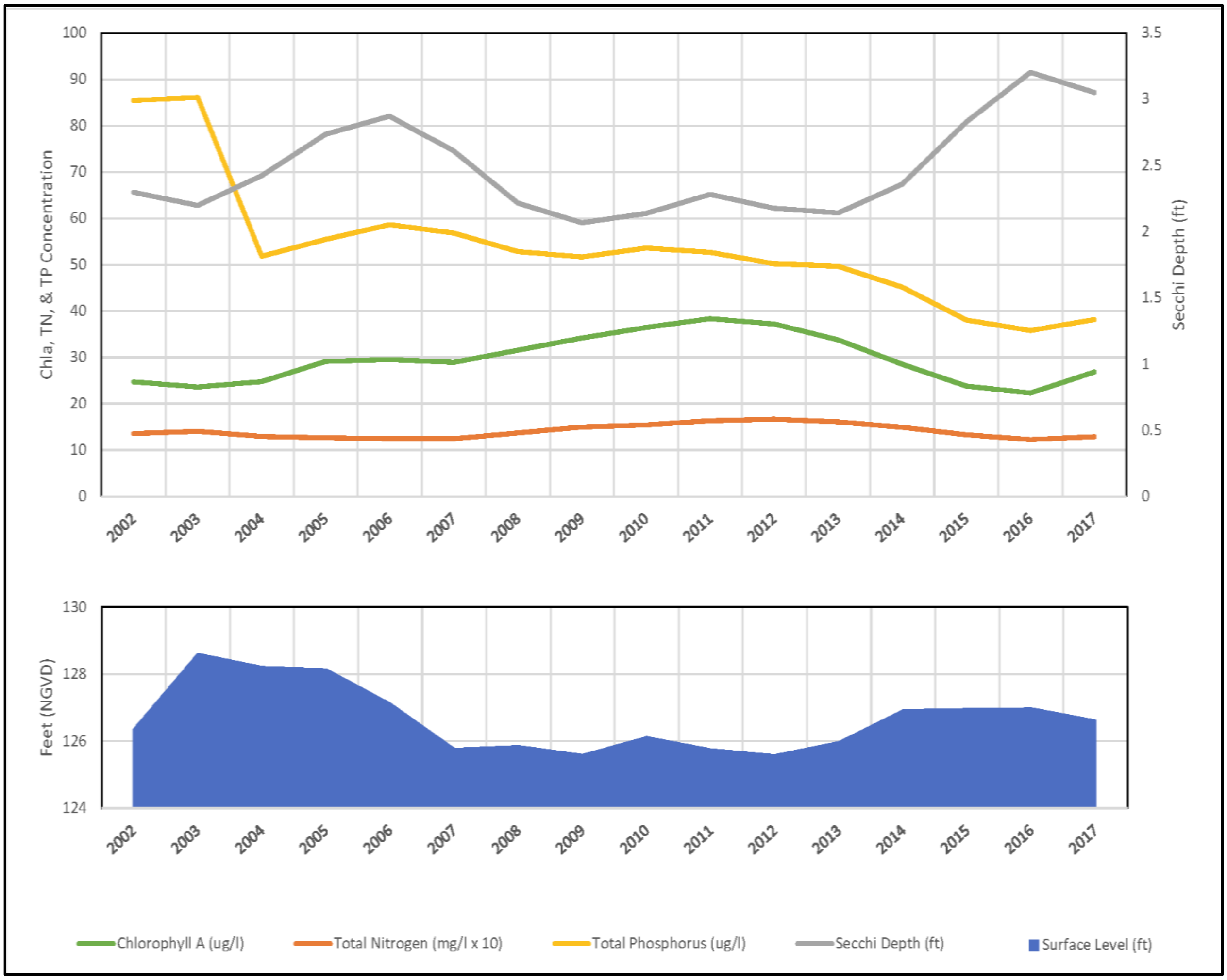

Figure 2-3 Northern Chain of Lakes Long-Term NNC Trends

Just as important as the emergent vegetation found along most lakeshores is the submerged aquatic vegetation (SAV) found under the water's surface. Figure 2-4 compares the relative biovolume as well as the invasive percentage of SAV for the Northern Chain. Logistical constraints have prevented the Natural Resources Division (NRD) from surveying the Hamilton chain, however plans are in place to assess these lakes in 2018. The lakes of the Northern Chain as a group possess relatively low biovolume percentages on average [13.8%] compared with the Southern Chain [23.1%] and Interior Lakes [17.5%]. The bathymetry (depth profile) data shows that the Northern Chain are all fairly shallow and flat-bottomed lakes, which would normally provide copious habitat for aquatic plants to grow. However, the shallowness of these lakes may also prove to be a detriment as sediments are easily suspended—reducing water clarity and limiting the depth at which aquatic plants can utilize sunlight for photosynthesis. Data supports this as the 2017 average Secchi depth for the Northern Chain [3.0 ft] is significantly lower than both the Southern Chain [3.9 ft] and Interior Lakes [4.6 ft].

The percentage of invasive SAV averaged 41.1% of the total submerged biovolume for this lake group. These numbers are considerably higher than the average invasive percentage across all lakes in the study area [15.2%]. The City works closely with the Polk County Natural Resources Division to identify and treat areas with dense invasive populations. Utilizing the 2017 survey data, the County treated Lakes Conine, Haines, Rochelle, and Smart—targeting the entire hydrilla community of each lake. Already there has been an apparent decline in the hydrilla populations, however this information cannot be confirmed until these lakes are surveyed again in 2018. One caveat to the treatment of invasive species is the release of excess nutrients as they decompose. In lakes with large populations of hydrilla like the Northern Chain, a more gradual treatment of invasives may help to prevent wild swings in water quality as was witnessed in the Northern Chain during this period. This further necessitates a monitoring program which can facilitate a rapid treatment response before invasives become dominant in the aquatic vegetation community.

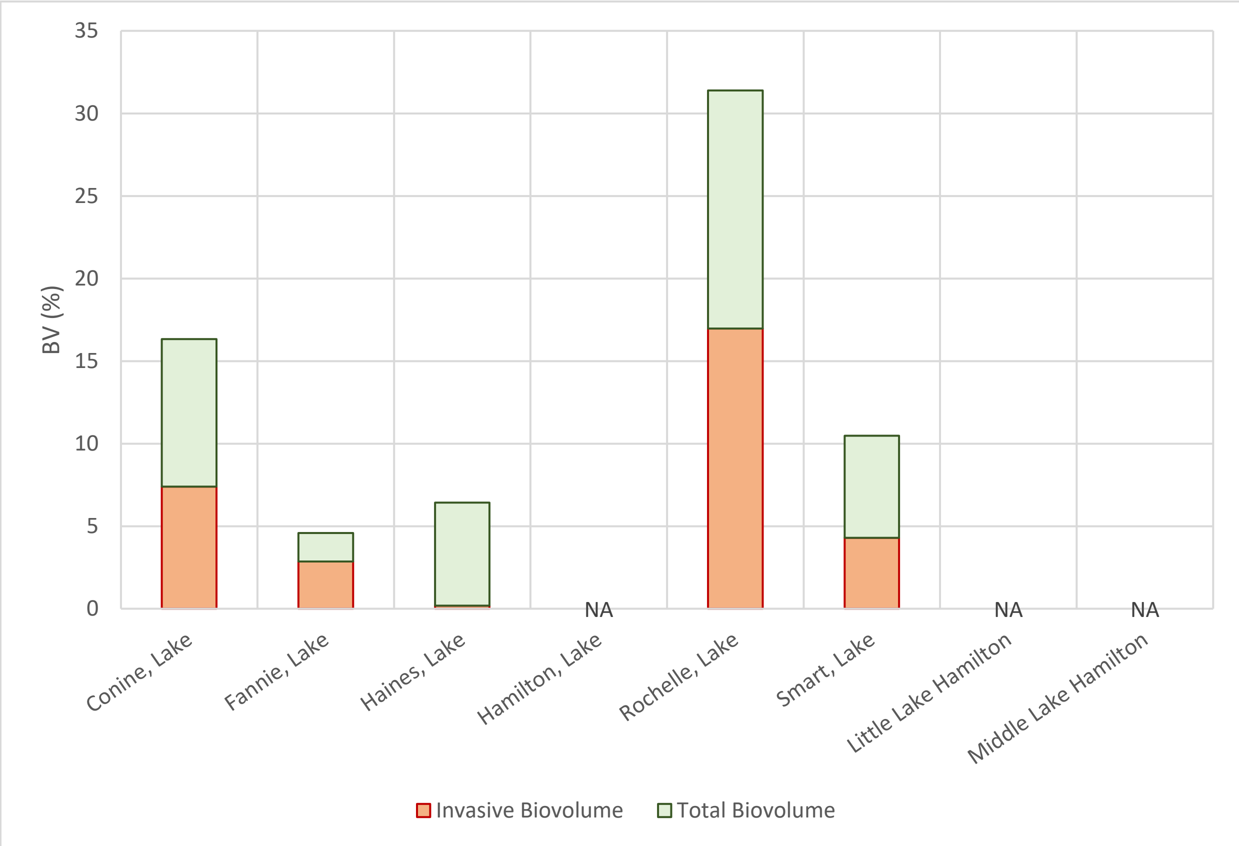

Figure 2-4 Northern Chain of Lakes Biovolume Percentage by Lake

2.2 Southern Chain of Lakes

The vast majority of the Southern Chain are considered ridge lakes. Their qualities consist of steeper slopes, deeper bottoms, and smaller littoral zones. In addition, most of these lakes are located closer to Winter Haven's city center—with a greater concentration of stormwater infrastructure and higher density land use. These factors impact water quality in a different manner than the Northern Chain. The following section seeks to explain these interactions in a data-driven manner.

Separately, the 14 lakes of the Southern Chain experienced both positive and negative changes in water quality; however, combined they averaged a 26.1% increase in Chla, a 0.6% decrease in TN, and a 2% increase in TP. Overall, the only significant change was the increase in Chla. Figure 2-5 depicts the annual percent change in average NNC parameters from 2016 - 2017. Analysis confirms six lakes contributed to the majority of the Chla increase: Lakes Idylwild, Jessie, Mirror, Spring, Summit, and Winterset. On a positive note, Lakes Cannon, Eloise, Hartridge, and Roy displayed an overall decrease in all NNC parameters during this period.

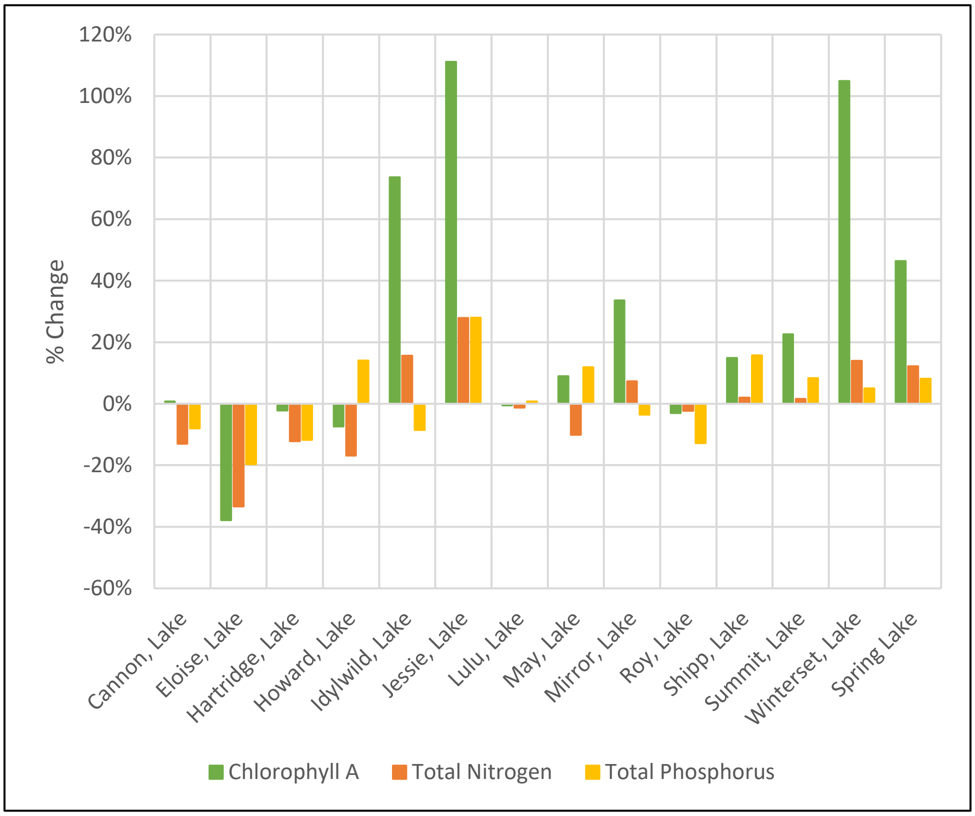

Figure 2-5 Southern Chain of Lakes NNC Percent Change

In relation to the NNC metric, there was little change in relation to the impairment thresholds for this group [Figure 2-6]. Lake Jessie exceeded impairment thresholds for all three NNC parameters in 2017, while Lake Idylwild exceeded impairment levels in Chla and TN. On the opposite end of the spectrum, Lakes Cannon and Eloise observed a decrease in TN concentration below their respective impairment thresholds.

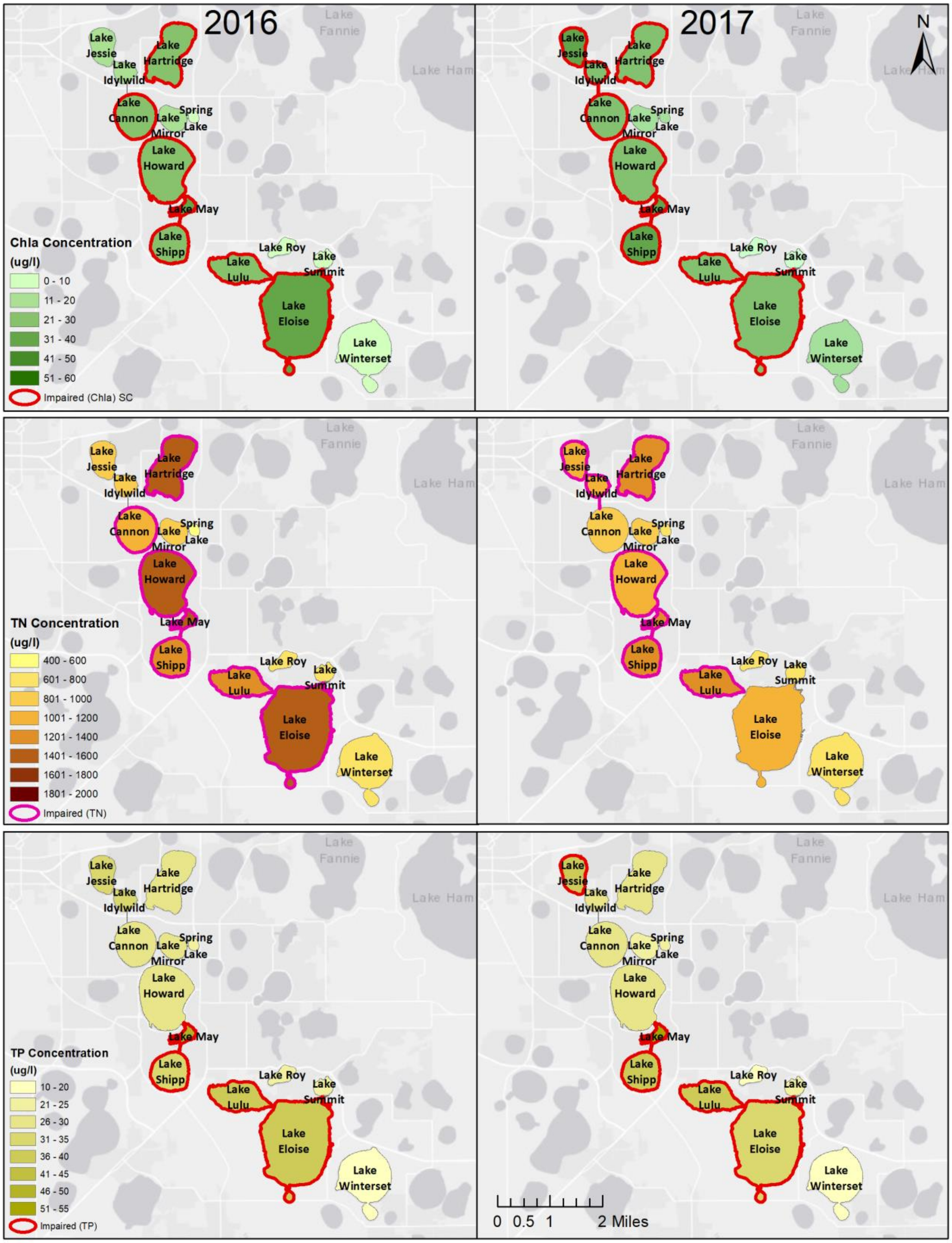

Figure 2-6 Southern Chain of Lakes NNC Impairment Comparison Map

† Impairment indicators in this figure do not represent the official ruling by the FDEP.

Despite the short-term increases in NNC concentrations, the long-term trends in Chla, TN, and TP have exhibited a gradual decrease since 2002; with Secchi depth increasing consistently during the same time period [Figure 2-7]. Observed as the overall change in the 2-point moving average of each metric, this demonstrates that nutrient reduction practices do have a positive impact on water quality even though it may not be immediately apparent. The effects of hydrological fluctuations on these metrics can be observed as a slight increase in NNC parameters after a downturn in lake level, with an opposite relationship between water clarity and surface level. As with the Northern Chain, a steep decrease in the average lake stage from 2016 – 2017 has elicited an increase in Chla, TN, and TP.

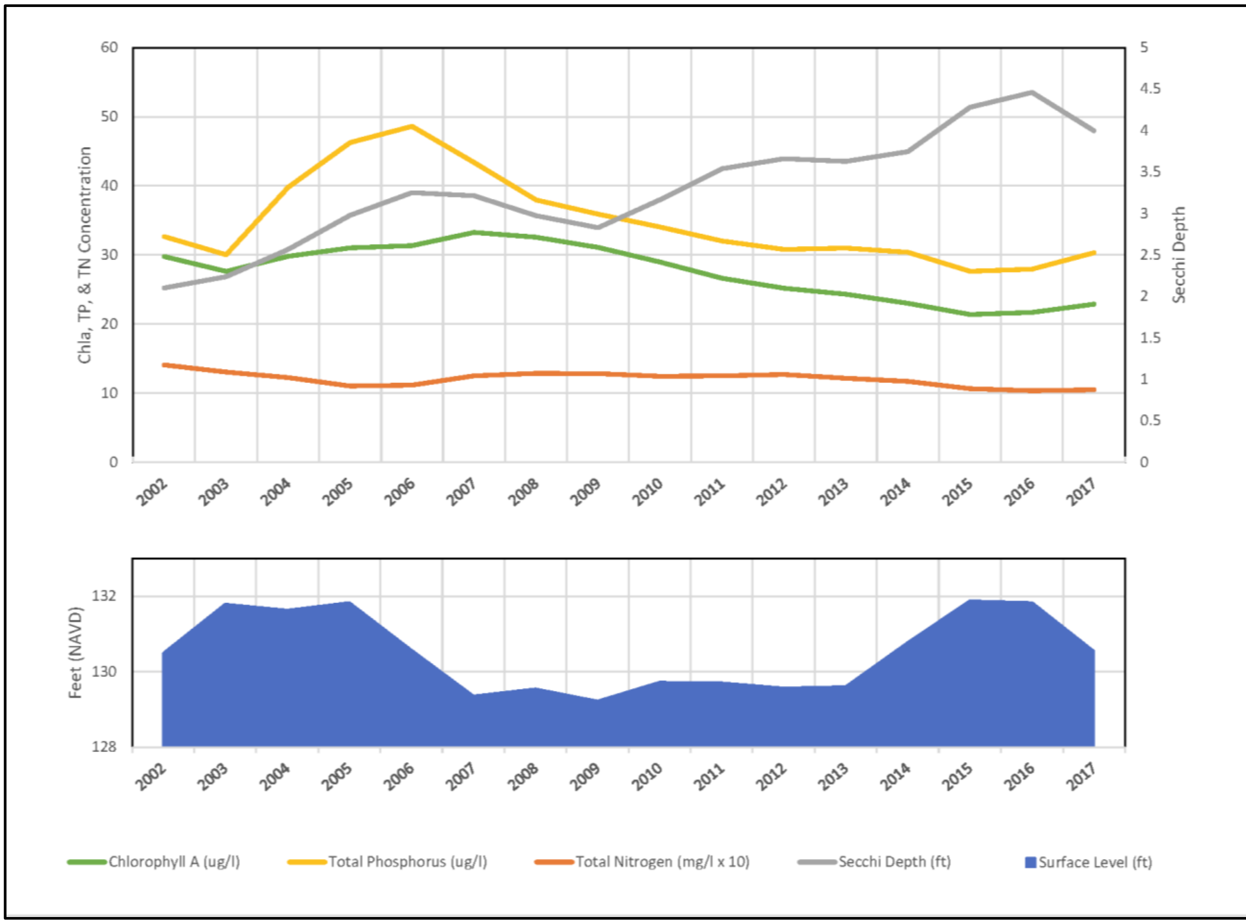

Figure 2-7 Southern Chain of Lakes Long-Term NNC Trends

The Southern Chain of Lakes possess relatively healthy populations of SAV with an average biovolume of 23% across all of the lakes in this group. Most of these waterbodies are located in the area known as the Winter Haven Ridge. Incidentally, these ridge lakes categorically have deep basins and sandy bottoms which are ideal for the growth of many native species of submerged aquatic vegetation. As such, none of the lakes in this group possess less than 10% biovolume—contributing to generally improved water quality over lakes with little to no SAV. Figure 2-8 illustrates the percentage of each lakes volume taken up by SAV as well as the percentage of this biovolume made up of invasive species. Compared with the Northern Chain's average invasive percentage [41.1%], the Southern Chain possesses considerably less [14.3%]. Lake Spring was the only lake with a >40% invasive make-up and has since been treated since then. Keeping the invasive populations below a majority percentage means that when these lakes are treated with herbicide, nutrient release is not as severe. This exemplifies how a rapid response system should work; killing off invasives before their populations become out-of-hand. Again, continued monitoring is key to maintain these healthy vegetative communities.

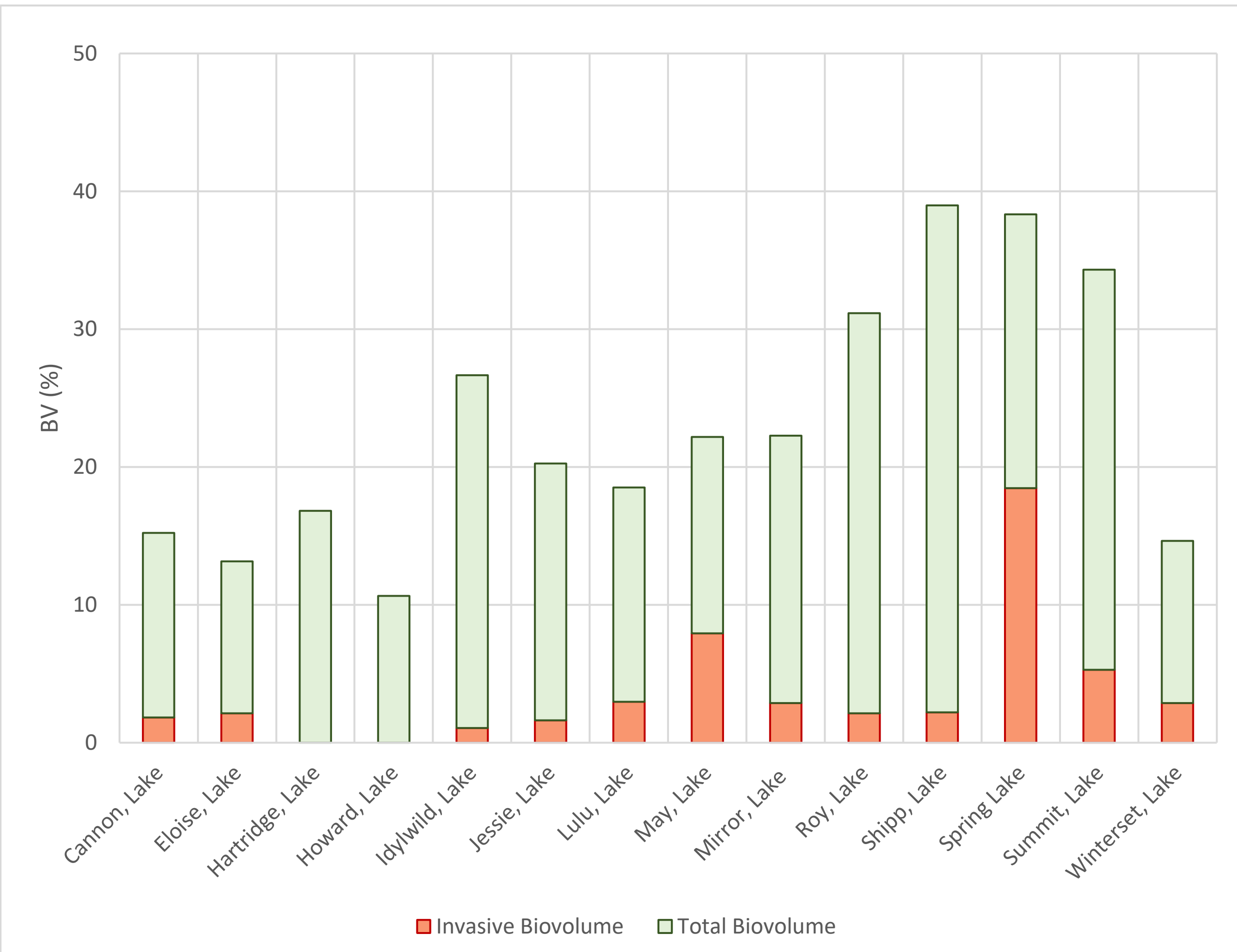

Figure 2-8 Southern Chain of Lakes Biovolume Percentage by Lake

2.3 Interior Lakes

As a miscellaneous collection of waterbodies separate from either chain, the Interior Lakes have been grouped together due to their isolated nature. The majority in this group are considered ridge lakes, but the hydrologic, topographic, and biological qualities vary wildly due to the diversity of their locations and surrounding features. Consequently, these lakes represent a cross-section of the waterbodies in the Winter Haven area and considering their qualities as a group presents a unique viewpoint on the overall lake health of the region. Despite this categorization, most of the Interior Lakes must be considered independently when developing management strategies as blanket plans won't work for all.

As a group, the Interior Lakes appear to have experienced a significant decline in water quality from 2016 – 2017 with a 52.1% increase in Chla, 16.7% increase in TN, and a 17.2% increase in TP. The extreme changes in NNC concentrations, expressed as the cumulative average of all lakes in this group, can be primarily attributed to one waterbody—Lake Idyl. The median values for these parameters more accurately demonstrate the water quality fluctuations observed in the majority of these waterbodies and dampen the effects of the outlier. A 24%, 5.9%, and 9.4% increase in median Chla, TN, and TP respectively, place these fluctuations more in line with changes observed in the other lake groups during this time period. Figure 2-9 shows the percent change in the NNC parameters for each lake from 2016 – 2017. This graph demonstrates the significant increases Lake Idyl experienced in all three parameters. Water quality fluctuations in Lakes Blue, Buckeye, Deer, Link, Martha, Maude, Otis, and Pansy weren't out of the ordinary when considering the environmental factors during 2017 (an extremely dry dry season).

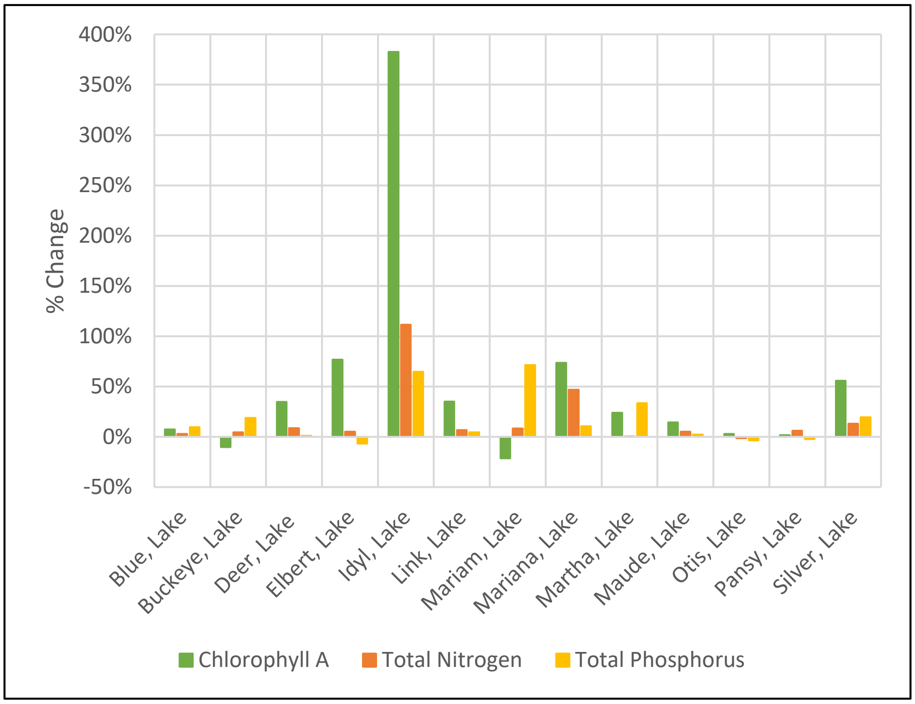

Figure 2-9 Interior Lakes NNC Percent Change

Figure 2-10 Interior Lakes NNC Impairment Comparison Map

† Impairment indicators in this figure do not represent the official ruling by the FDEP.

The effects of these water quality fluctuations in relation to the NNC impairment thresholds are detailed in Figure 2-10. A Chla increase in Lake Silver was enough to raise it above the impairment threshold. A lack of vegetation in this lake does little to buffer against the growth of algae. In 2017, TP concentrations increased beyond impairment levels in Lake Marianna. Lake Blue remains impaired for all three metrics. Historically, industrial and high density residential land-use in the area has contributed to high concentrations of legacy nutrients in this waterbody[13]. The removal of lake sediments would be an effective management strategy to help bring Lake Blue back to unimpaired status. This practice is extremely cost-prohibitive, however collaborative efforts with other agencies and outside funding are possible options to be considered in the future. Unsurprisingly, the massive decline in water quality in Lake Idyl has led to NNC concentrations above impairment thresholds. The primary driver for this water quality decline appears to be a significant release of nutrients from the breakdown of aquatic plant matter. In its latest survey, the City NRD found an abundance of detritus (decaying plant matter) in

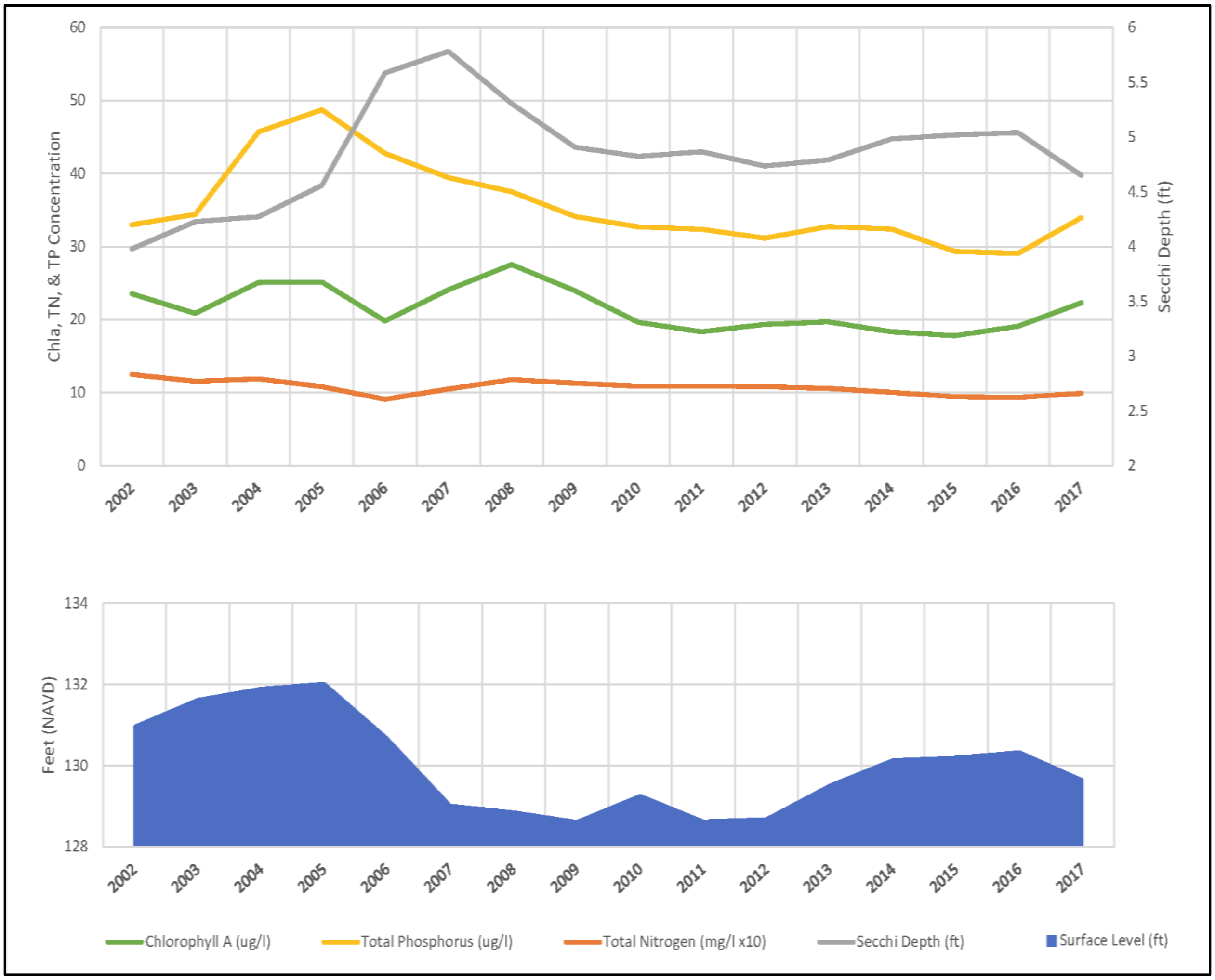

Figure 2-11 Interior Lakes Long-Term NNC Trends

Lake Idyl. Records from the County NRD indicate no deviation from their invasive treatment protocols and would not have elicited such a response in the aquatic vegetation community. At this point it is difficult to say with certainty what has caused the die-off, but the City will continue to monitor the situation and attempt to determine the source.

Long-term water quality data indicates a slight improvement in Chla and TN and a moderate increase in water clarity from 2002 – 2017. TP concentrations display a general downward trend from 2005 – 2017, but a considerable increase in the last year has placed the average concentration of TP above where it was in 2002. Figure 2-11, which also includes the annual average surface level graph for this group, illustrates these trends using a 2-year moving average. Like with the other lake groups, the decline in water quality in the last year coincides with a moderate decrease in surface elevation.

With respect to submerged aquatic vegetation, the Interior Lakes possess both some of the highest and also the lowest biovolume percentages in Winter Haven. Figure 2-12 displays the BV percentages of each lake in this group as well as the percent comprised of invasive species. Ultimately, the average BV evens out to 17.1% for this group which actually sits between the average BV of the Southern and Northern Chains—providing further evidence that the Interior Lakes are a representative cross-section of the Winter Haven region. The average invasive species composition of this group [15.2%] actually sits closer to the lower end of the spectrum which is great news from an ecological standpoint.

Lakes Deer and Maude represent the two highest concentrations of relative biovolume in the study area. Not only that, but both of these lakes possess small proportions of invasive plants. More closely resembling pre-development plant communities out of any other lakes in the area, it comes as no surprise that these waterbodies have some of the best water quality in this group. On the opposite end of the spectrum, Lakes Blue, Martha, and Silver all possess the lowest percentages of SAV in the study area. The lack of vegetation is a result of different factors in each lake: In Lake Blue, the increased nutrient load has facilitated the growth of algae and reduced the water clarity to the point that submerged plants can only grow around the periphery of the lake. Lake Mariam has been the subject of some intense invasive treatment trials which included the introduction of grass carp and an experimental herbicide application—preventing most submerged plants from gaining a strong foothold. Lake Silver has a very deep basin with steep sloping sides which limit the littoral zone where submerged plants are able to grow. The silver lining is that despite having low biovolume, none of these lakes were observed with submerged invasive species.

The Interior Lakes represent how proper invasives management can be a benefit to the health of the lakes—as is the case with Lakes Deer and Maude. These waterbodies can also show us the severe impacts improper management can have on water quality—demonstrated with Lake Idyl. Learning from these successes and failures is critical to understanding how our actions ultimately affect our lakes and in what ways we can become better stewards of our natural resources.

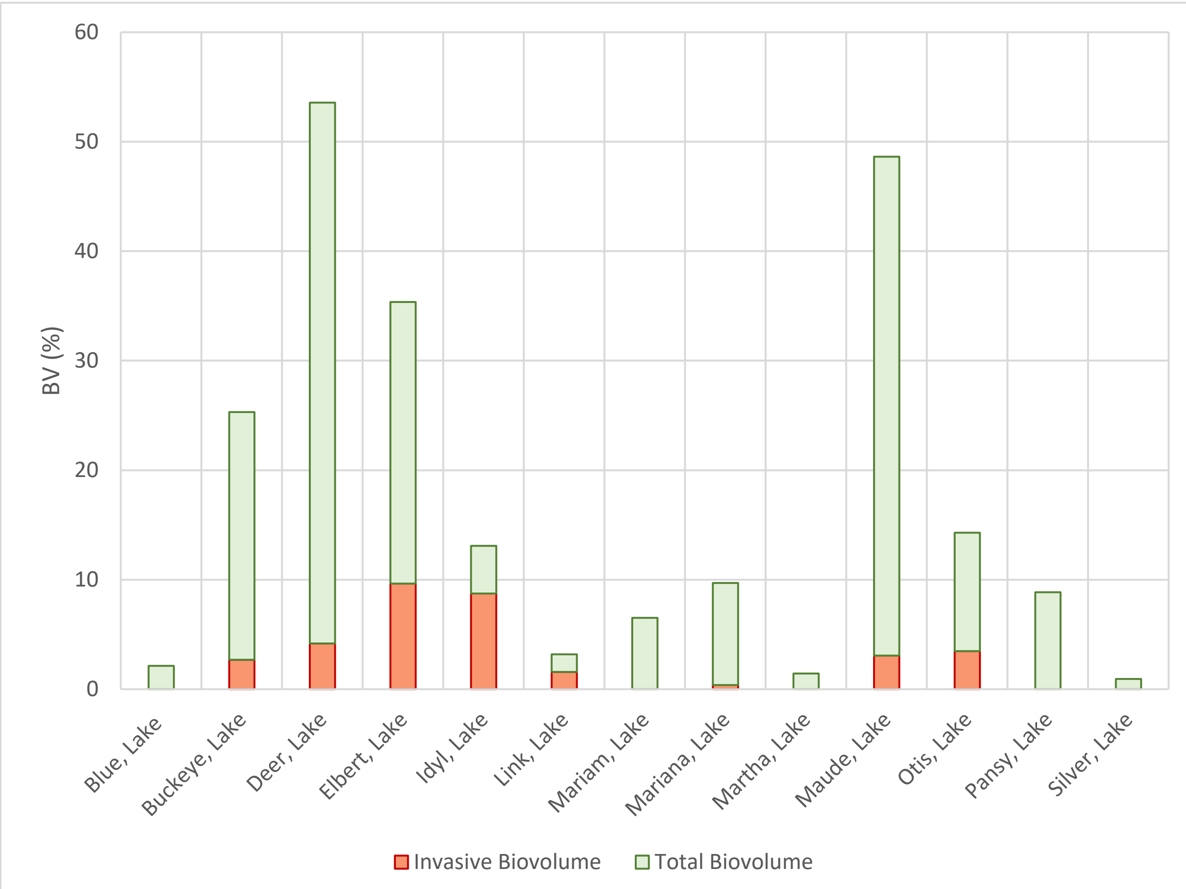

Figure 2-12 Interior Lakes Biovolume Percentage by Lake

3. Management Strategies

Winter Haven's lakes are beneficial resources enjoyed by various groups in many different ways. Features of the lakes that are desirable by one group may not be considered attractive to another. A robust vegetative community, for example, may be considered favorable for fishing, but not for swimmers, skiers and those enjoying watersports. On the other hand, clear and uncolored water may be desirable despite it conflicting with the natural state of these waterbodies. Consequently, a balance must be struck to maintain the designated use classification of the lakes in all categories—water quality, ecology, recreational use, etc. Therefore, a systematic management approach is necessary to ensure lake health on all fronts. This section presents background information on some of the management practices employed by the City as well as reinforces how each strategy provides public benefit and supports the Mission, Purpose, and Vision (MPV) of the Division.

Mission:

Maintain and improve local natural resources through management based on a sound understanding of social, economic, and ecological systems.

Purpose:

Balance the needs of diverse user groups to sustain natural resources the community can be proud of.

Vision:

To be the premier knowledge base for local natural resources, with an engaged public, supporting natural systems through a community ethic.

Values:

Courteous, Cognizant, Cooperative, Resourceful, Responsive, Accurate, Adaptive

3.1 Watershed Initiatives

Stormwater Assessment and Improvement Project:

Summary:

Winter Haven's stormwater system is a network of drainage pipes, ditches, and other conveyances that capture surface water runoff and move it to storage ponds or, more often, directly into lakes. The Stormwater Assessment and Improvement Project (SAIP) was drafted by the City, in conjunction with various agencies and organizations, employing a holistic approach to improve existing stormwater infrastructure as well as to better plan additions to this network. This project 100% funded by a legislative appropriation administered by the Florida Department of Environmental Protection (FDEP) involves a four-pronged approach that includes:

1. Refining the current geospatial database of stormwater infrastructure: The City utilizes ArcGIS—a geographic information system (GIS) program that allows users to create, analyze, and manipulate geospatial data—to store information on the network of stormwater pipes and outfalls. The engineering firm, Chastain Skillman, has been employed by the City to update the currently outdated and fragmented inventory map to one that is more cohesive. Additionally, this updated database will include a standardized procedure for entering new stormwater information.

2. Ground truthing existing and previously unidentified stormwater infrastructure: Chastain Skillman is scheduled to work closely with the City to evaluate the current condition of the various pipes, drains, and other conveyances. Factors such as pipe and drain size, material type (e.g. concrete, steel, etc…) and flow capacity. This evaluation will allow the City to more efficiently prioritize management and repairs to the existing stormwater infrastructure.

3. Collection and compilation of LiDAR data to develop a high resolution digital topographic map of the City: Light Detection And Ranging (LiDAR) users lasers to measure variable distances to earth from a known point—usually from an airplane or drone. This data is then compiled to form a highly detailed topographic map of the area studied. The City of Winter Haven has piggybacked onto an existing contract between the Sanborn Map Company and the Southwest Florida Water Management District (SWFWMD). This cooperation with the District provides the City with services and data it could not have achieved alone with a limited budget. Ultimately, the topographic information will allow for more precise modelling of surface water flow and pollutant loading to the lakes.

4. Identification and prioritization of targets for improvement: Incorporating all of the previously mentioned methods of this approach will allow the City to prioritize areas of necessary stormwater improvement. This prioritization process includes the creation and refinement of a comprehensive, city-wide diagram of stormwater connections, pipe sizes, pathways, and existing conditions as well as a high resolution topographic map. a more detailed surface flow modelling can highlight the pathways that receive greater stormwater volume and heavier nutrient loading. The former will help users to understand where potential drainage issues may occur, while the latter will provide more detailed stormwater modelling; highlighting waterbodies that receive heavier surface flow which could lead to greater nutrient loading and propensity for water quality issues. This suite of information will allow City employees to pinpoint problem areas and make informed decisions when prioritizing improvements. Understanding where resources should be focused is paramount when time and funds are in limited supply. Moreover, the SAIP will greatly enhance the speed and efficiency of repairs, maintenance, and improvements to Winter Haven's stormwater systems.

Public Benefit:

Using this data to drive decisions related to stormwater maintenance and improvement allows the staff to make efficient decisions about projects with the highest return on investment.

Support of Mission, Purpose, and Vision:

Stormwater is a major component of the "social, economic, and ecological systems" identified in the Mission and having a "sound understanding" of this system positions staff to fulfill the Division's Purpose. Having this understanding also positions the City to be the "premier knowledge base for local resources" in support of the Vision which gives the community an advantage when working to address State and Federal mandates.

Strategic Goals:

- By the end of 2018 perform stormwater modeling to identify areas with potential for water quality and quantity improvements.
- By the end of 2018 implement an improved maintenance strategy utilizing an asset management system to continuously update data.

Alum Treatment:

Summary:

Aluminum sulfate (Al_2SO_4) aka alum has been a popular treatment option for surface waters in order to reduce concentrations of phosphorus, total suspended solids (TSS), algae and nitrogen originating from stormwater inputs. Alum injection is a stormwater management solution that can be especially useful in locations where the area for large settling ponds does not exist or as an alternative to less stable chemical coagulants. On contact with water, alum forms a precipitate or gelatinous floc that rapidly binds to nutrients and suspended matter, after which it settles out of the water column (Figure 3-1)[9]. The efficiency of pollutant removal via alum treatment varies dependent upon dosage and nutrient type. Total phosphorus (TP) removal is considered to be the most efficient with estimated ranges from 85-95%, while total nitrogen (TN) removal is much less efficient at 35-70%[5]. After nutrient adsorption to the alum floc, it falls out of solution and can be collected in settling reservoirs or allowed to settle in the treated waterbody. This alum floc is stable in a pH range of 5.5 – 7.5[5]. Since Winter Haven's lakes are generally alkaline with stable pH levels, they make good candidates for alum treatment as there is little risk of the precipitate re-dissolving into the water column.

The City of Winter Haven currently operates three alum treatment facilities located at major stormwater outfall positions on the Southern Chain. One is located on the eastern shore of Lake Howard at Heritage Park, one on the northern shore of Lake Lulu at the Chain of Lakes Complex and one on the eastern shore of Lake May near 6th Street SW. Preliminary alum project evaluation reports were drafted prior to the construction of the alum treatment systems which modelled estimated pollutant reductions at each potential outfall location (published in 1998 for Lake Howard and 2002 for lakes Lulu and May). According to the reports, the alum treatment was anticipated to reduce annual stormwater pollutant loading of TP by 92%, TN by 45%, and TSS by 87% on the eastern side of Lake Howard[6]; a reduction of TP by 73%, TN by 37%, and TSS by 69% on the northern side of Lake Lulu; and a reduction of

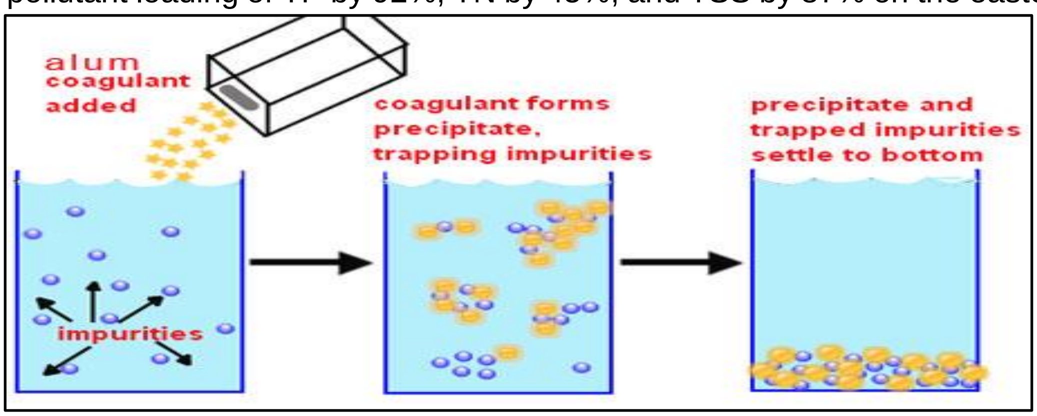

Figure 3-1 Conceptual diagram of alum binding to aquatic pollutants (alum floc production)

TP by 95%, TN by 44%, and TSS by 97% on the eastern side of Lake May[7]. These reduction estimates only account for the stormwater basins leading directly to their respective alum treatment locations and not reductions in total stormwater loading for each lake. Refer to Table 3-1 for estimated total stormwater pollutant loading reduction for each lake via alum treatment. It is worth noting that Polk County manages one additional alum injection site that treats incoming stormwater on the western side of Lake Cannon. The City works closely with the County to monitor pollutant loading at this site.

Table 0-1 Estimated reductions in total phosphorus, total nitrogen, and total suspended solids via alum treatment at Lakes Howard, Lulu, and May

	Total Stormwater Pollutant Loading (kg/yr)*			Estimated Reduction at Alum Outfall (kg/yr)†			Total Stormwater Reduction via Alum Treatment		
Waterbody	TP	TN	TSS	TP	TN	TSS	TP	TN	TSS
Lake Howard	2703	22,481	433,279	400	921	65,957	15%	4%	15%
Lake Lulu	448	2906	86,726	94	222	17,832	21%	8%	21%
Lake May	328	2036	71,523	147	205	29,171	45%	10%	41%

Public Benefit:

Making TP and TN biologically unavailable means it cannot be used for excessive growth of vegetation or algae in lakes. These are the main pollutants of concern in local systems and limiting their availability in the system helps to prevent further decline in lake water quality.

Support of Mission, Purpose, and Vision:

Alum Injection is a management strategy that strives to “Maintain…local natural resources” as stated in the Mission. Alum injection will not solely cause improvements in lakes, but it does help to limit further impacts from being realized. By reducing stormwater impacts, lake systems become more predictable making it is easier to manage systems to “the needs of diverse user group” as outlined in the Purpose. Alum injection is an interesting process and it provides an opportunity to talk with residents about it and other management tools and the effectiveness of different management strategies. This helped to create the “engaged public” identified in the Vision.

Strategic Goals:

- By the end of 2018 establish an internal understanding of the system’s operation.
- By October 1, 2018 devise a strategy to evaluate the effectiveness of the systems.
- By FY19-20 budget preparations include any improvements needed in FY 20.

Street Sweeping:

Summary:

One significant source of pollutant loading to lakes comes from sedimentation accumulated in streets and drained to lakes via stormwater runoff. Street sweeping is what is referred to as a non-structural best management practice (BMP). In 2013, the City entered into a three year contract with USA Services to sweep curbed streets in specified areas to mitigate this pollutant loading source. Areas swept included downtown and much of Winter Haven's residential areas. Specifically, areas including downtown and major Department of Transportation (DOT) roads were prioritized for sweeping on a bi-weekly basis. The remaining residential areas were covered on a semi-annual basis. These sweeping areas encompass a significant portion of the major outfall basins that drain stormwater run-off into Winter Haven's lakes. Sweeping these areas on a regular basis provided the service of reducing nutrient loading into the lakes via sedimentation on streets running into stormwater drains. In 2016, the City renewed a service contract and issued an updated task order that improved upon these benefits by increasing residential sweeping to monthly and expanding sweeping coverage (Figure 3-2).

Public Benefit:

This non-structural BMP provides a physical removal of potential pollutants that is exponentially more efficient then dealing with them once they enter a waterbody. It also limits debris from blocking the stormwater conveyance system which can be problematic and expensive to address. This is a true maintenance practice that strives to deal with issues by attentively and routinely managing them rather than allowing the issue to reach the end of the line where they are more expensive and difficult to manage. Removing this debris from roadways also prevents situations that undermine the quality of the roadway. There is an ancillary aesthetic benefit as well.

Support of Mission, Purpose, and Vision:

Street sweeping is a true maintenance activity that is managed based on the understanding of the "social, economic, and ecological systems" identified in the Mission. Debris coming out of a stormwater pipe is one of the most visible forms of pollution and street sweeping helps to alleviate this issue in an effort to "sustain natural resources the community can be proud of" as identified in the Purpose. The location and efficiency of street sweeping activities is closely monitored to understand the effectiveness of the program making the City "the premier knowledge base", as outlined in the Vision, for understanding pollutant loading of local water bodies which is beneficial in addressing State and Federal mandates.

Strategic Goals:

- Develop an outline of opportunities for alternative approaches to be contemplated for the FY 18-19 budget
- Initiate the decided on approach so new services can begin January 1, 2019
- Continue to conduct monthly surveys of street sweeping activities to gauge effectiveness and communicate deficiencies with contractor

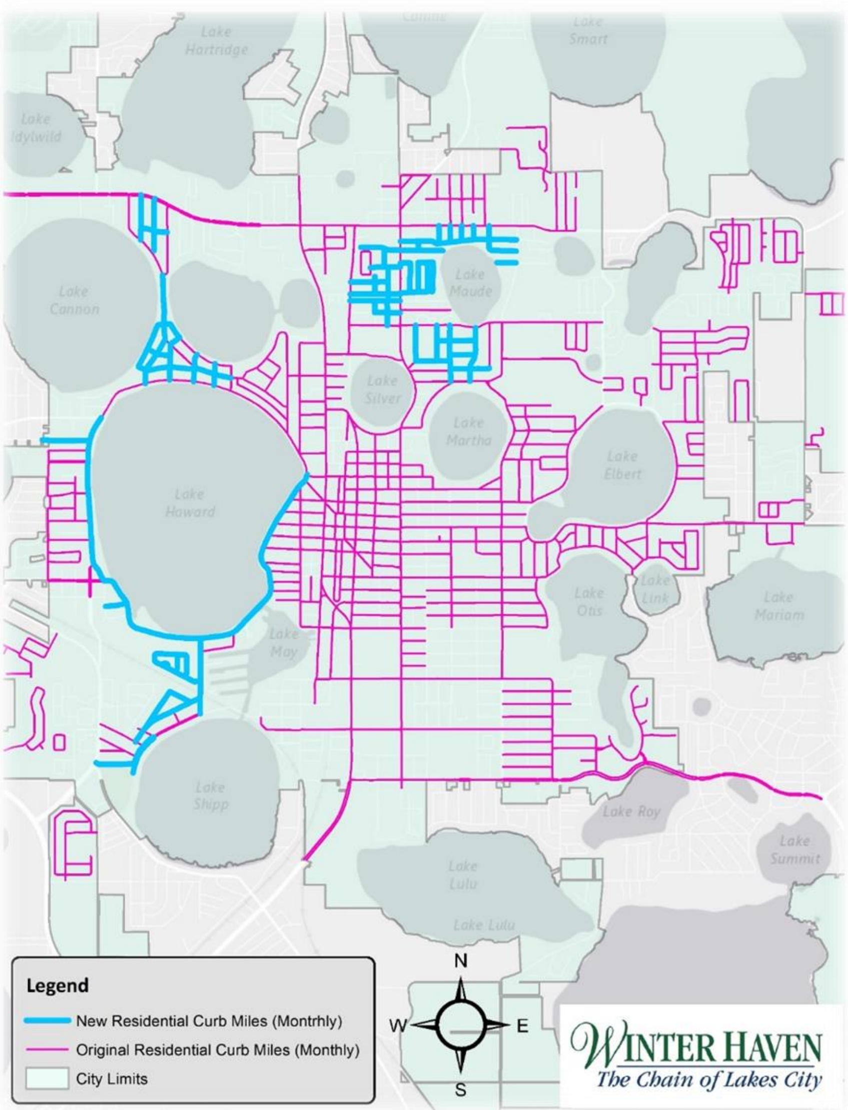

Figure 3-2 Map of street sweeping routes prior to and after sweeping contract renewal

Low Impact Development Projects:

Summary:

The United States Environmental Protection Agency defines Low Impact Developments (LIDs) as systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat by managing stormwater as close to the source as possible. By engineering infrastructure that implements vegetation and porous soils, polluted runoff can be treated before it reaches traditional stormwater systems and ultimately lakes and canals. Traditional or “gray” stormwater infrastructure relies on impervious materials, gutters, pipes, and ponds and only transfers runoff from one area to another. Winter Haven is in the process of moving to more “green” development projects such as raingardens, bioswales, exfiltration structures (e.g. French drains), and pervious pavement. While nutrient loading benefits are localized, there are ancillary benefits imparted through the use of “green” engineering. Instead of stormwater running over impervious surfaces, LIDs provide an inlet for surface runoff to percolate directly into the water table or surficial aquifer. If placed in the direct pathway to an existing stormwater drain, LIDs are able to capture sediments, heavy metals, and solid refuse during the first flush of a rainfall event before it can drain directly to the lakes. Using proper xeric soils, flooding along roadways during 1 to 10 year storm events can be reduced, while utilizing xerophilic plants in the construction of LIDs also helps to beautify the urban landscape. In some cases, LIDs can be utilized in lieu of traditional stormwater ponds in city planning. If engineered correctly, low impact storm systems can occupy smaller footprints while still mitigating a similar volume of stormwater—benefitting developers by allowing more area for construction while still promoting the above mentioned services.

Currently, the City has constructed 71 raingardens and French drains in and around Winter Haven’s urban center. Plans are in place to construct 45 to 60 more in the next two years. Table 3-2 highlights the estimated nutrient load reduction capabilities of LIDs in each lake group. While nutrient removal capabilities are minimal on an individual basis, LIDs can collectively have a greater impact in larger numbers. Moreover, relatively low construction costs in addition to the aforementioned benefits make low impact projects an elegant solution for future stormwater treatment in the urban cityscape.

Table 0-2 Estimated total phosphorus and total nitrogen load reductions via low impact development projects for the Southern Chain and Interior Lakes

Estimated Reductions			
Lake Group	# of LIDs	TN (kg/yr)	TP (kg/yr)
Southern Chain of Lakes	25	6.82	1.05
Interior Lakes	46	17.87	2.74

Public Benefit:

LID's provide stormwater treatment above and beyond what was historically constructed in the City. By replicating natural systems in the management of stormwater, pretreatment of pollutants is achieved along with hydrologic restoration. Both of these have direct benefits to lake water quality. Furthermore, these projects can provide social and economic benefits by improving the aesthetics of an area either through improved landscaping, reduced puddling, or both.

Support of Mission, Purpose, and Vision:

LID implementation directly supports the Mission by using "a sound understanding of social, economic, and ecological systems." To "Maintain and Improve local natural resources". Improving hydrology and water quality help to "balance the needs" identified in the Purpose. LID construction is a realization of the Vision, in that the City has received outside support because other agencies recognized the City is the "premier knowledge base for local natural resources".

Strategic Goals:

- By October 1, 2018 apply for SWFWMD funding to construct Raingardens in FY 2020.
- By the end of 2018 implement an improved maintenance strategy for LID's.
- By the end of 2018 construct 16 FDEP funded Raingardens.
- By the end of 2018 construct 10 SWFWMD funded Raingardens in house.
- By the end of 2018 design 12 SWFWMD funded Raingardens to be contracted out.
- Be prepared to implement an in house construction program by the start of the FY18-19 Budget Development.

Stormwater Treatment Parks:

Summary:

Stormwater treatment parks (aka nature parks) are engineered wetlands that perform similar functions as other forms of low impact development as well as provide additional benefits to the surrounding community. The primary focus of nature parks is to reduce the impact of non-point source pollution on target waterbodies by treating surface runoff and stormwater effluent. Comprised of one or more reservoirs, designed with long retention times, and seeded with communities of natural wetland vegetation, nature parks receive redirected stormwater discharge and allow it to slowly pass through the reservoirs before releasing the treated water to an adjacent lake. The multiple aspects of this treatment process include: nutrient reduction via plant uptake, reductions to turbidity and suspended solids via sedimentation, capture of solid refuse, and an increase in water color through the introduction of dissolved tannins (organic matter). Secondary goals for these treatment parks are to create wetland habitat, increase biodiversity of wetland flora and fauna, introduce opportunities for public education, and provide recreational areas and green spaces. In essence, nature parks exemplify how "green" engineering can easily solve human problems with natural solutions as well as seamlessly integrate beneficial ecology and urban development.

Maintenance to these nature parks is vital to their ability to effectively treat the incoming stormwater and involves clearing overgrown or nuisance vegetation from the periphery of the lakes and ponds. The benefits of proper landscaping include the opening of clogged stormwater pathways, curtailment of invasive species growth, aesthetic improvement, and a reduction in the available nutrients that would otherwise enter the adjoining waterbody. The latter of these benefits is especially important. The decomposition of plant matter releases nutrients the plant has sequestered over its lifetime back into the environment.

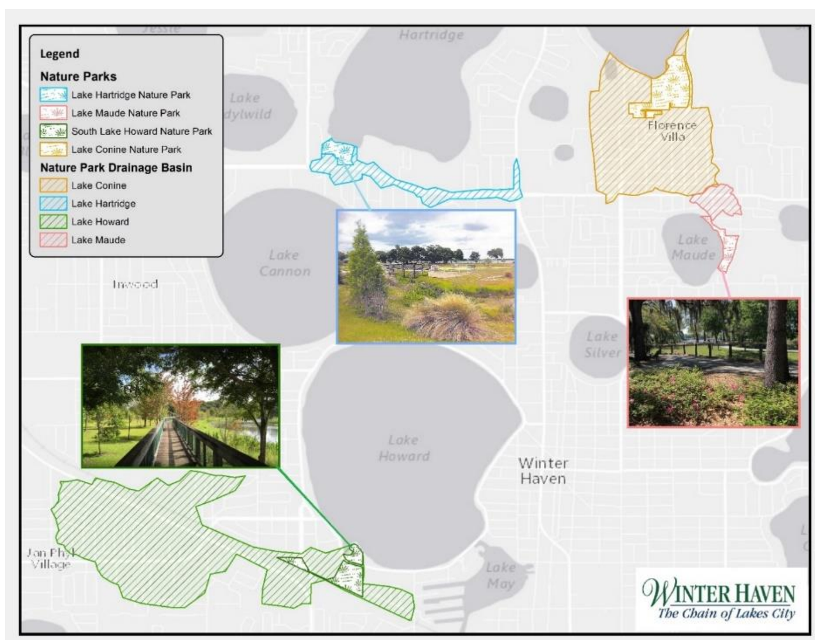

Figure 3-3 Map of Winter Haven Nature Park locations

Therefore, removing excess vegetation assists in reducing the total nutrient load to our waterbodies.

There are currently three stormwater treatment parks located in Winter Haven: South Lake Howard Nature Park (15.9 acres), Lake Hartridge Nature Park (9.4 acres), and Lake Maude Nature Park (6.4 acres). In addition to providing the above-mentioned services, each park was constructed with walking trails and boardwalks, picnic pavilions, and fishing piers. Plans are underway to construct a fourth stormwater treatment park on the south shore of Lake Conine which will be Winter Haven's largest nature park constructed to date (32.9 acres). As one of the recipient waterbodies of point-source (wastewater discharge) prior to 1992, Lake Conine is considered a high priority for water quality improvement. This proposed wetland park is expected to treat the stormwater runoff from an approximate 330 acres of residential area and considerably reduce pollutant loading to Lake Conine. Figure 3-3 depicts the locations of each of the current nature parks as well as the proposed Lake Conine project.

Public Benefit:

These parks provide treatment of stormwater prior to it entering local lakes providing a centralized location for debris and pollutants to be actively managed. These parks keep significant pollution from entering local waterbodies. Additionally there is a recreational component that these parks provide supporting social and economic wellbeing in the community.

Support of Mission, Purpose, and Vision:

These project are similar to LIDs in that they directly support the Mission by using "a sound understanding of social, economic, and ecological systems." To "Maintain and Improve local natural resources". Improving hydrology and water quality help to "balance the needs" identified in the Purpose. Their Construction is a realization of the Vision, in that the City has received outside support because other agencies recognized the City is the "premier knowledge base for local natural resources".

Strategic Goals:

- By the end of 2018 have all 3 of the existing nature parks in a fully restored maintenance phase.
- By the end of 2018 begin construction of the Lake Conine Treatment Wetland.
- Be prepared to budget for vicennial maintenance of Lake Howard Nature Park by FY18-19

NPDES:

Summary:

The National Pollutant Discharge Elimination System (NPDES) was created in 1972 under the U.S. Clean Water Act. The U.S. Environmental Protection Agency (EPA) is responsible for the permit but works with the Florida Department of Environmental Protection (FDEP) to administer it within the state. Polk County holds a permit for the region and the City serves as a Co-permittee within that permit. The permit addresses water pollution by regulating point sources that discharge pollutants to water of the United States. In Winter Haven that would mainly be the lakes.

The major component of the NPDES permit the City participates in relates to stormwater management. Specifically, to the functional maintenance of the infrastructure, educating the community about ways to reduce impacts, designing an active approach to reduce pollutant loading into local water bodies, and tracking lake health to look for a measurable impact.

Public Benefit:

The NPDES permit provides accountability and transparency to residents that every precaution is being taken by the organization to protect natural resources in all operations. The permit also requires the City to constantly improve their understanding of the potential local impacts and create plans for addressing those impacts.

Support of Mission, Purpose, and Vision:

By requiring the City to continually improve its understanding of the potential impacts it drives the Division to improve their “understanding of the social, economic, and ecological systems” directly supporting the Mission. “Sustaining natural resources” is a central focus of the Division’s Purpose and the tracking associated with the permit has the same focus. The transparency created by the permit and the assurance to the residents that impactful activities are appropriately tracked supports the “engaged public” and “community ethic” outlined in the Vision.

Strategic Goals:

- Submit the Cycle 4 year 1 permit by the end of March 2018 to allow focus to return to process improvement.
- Conduct an internal review of City codes and ordinances related to stormwater by the end of Cycle 4 year 2
- Distribute cycle 4 year 2 permit data requests by November 1, 2018

- Receive all data from majority of providers by the Thanksgiving Holiday
- Work with data providers to better understand the challenges in efficiently providing their portion of the permit data and develop strategies by the start of Cycle 4 Year 3 to increase efficiency.

319 Gray to Green:

Summary:

In response to findings that a number of lakes in Winter Haven had impaired water quality, the City adopted a Sustainable Water Resource Management Plan, lake water quality restoration and management goals, and amended its comprehensive land development code to protect the health of its surface water and groundwater resources. Through these efforts the City identified the need to develop and implement a public education program to help the community transition from a conventional “pipe and pond” (gray) stormwater management system to a green stormwater system designed to slow, spread, and soak stormwater, and help restore the natural flow-way of runoff and the water balance. Managing water in this way also allows for more robust and sustainable development in the future. This project will design and implement an education program targeted at City staff, local engineers, and developers, and provide them with the tools they need to bring about this philosophical shift in stormwater management.

Financial assistance was applied for and received to offset the cost of this program. The funding source is in the form of a 319 Clean Water Act Grant from the United States Environmental Protection Agency (USEPA) administered by the Florida Department of Environmental Protection (FDEP) through “DEP AGREEMENT N0. NF015”.

The agreement identifies four main tasks, to be completed by April 2018, and is summarized as follows:

1. Solicit community guidance and institutional support in developing and implementing the education program
    a) Green Education and Green Transition teams will be comprised of City staff and technical members of the community to better understand the challenges green stormwater system development poses.
2. Develop education and marketing materials
    a) Based on the lessons learned in the first task and through previous efforts, materials will be created to stimulate public and private sector awareness, involvement, and action in developing green infrastructure projects.
3. Implementation of the education program
    a) The education program will be implemented through a series of community workshops and land planning development reviews. The effectiveness of which

will be tracked through participation surveys conducted at the beginning and end of all project activities.

4. Final report

   a) A final report summarizing the results of the effort will be produced and submitted to the EPA.

Public Benefit:

Changing land uses come with changes in the way water moves in the landscape. The goal of this program is to make sure the City is providing education and options to customers on how to develop using tools Like Low Impact Developments and Best Management Practices (BMPs) to minimize impacts to the functions of the natural system.

Support of Mission, Purpose, and Vision:

This is an effort driven by the "sound understanding of the social, economic, and ecological systems" identified in the Mission. Development has economic and social benefits to the area and can also have ecological benefits if planned properly, this approach strives to "Balance the need of diverse user groups" as identified in the Purpose. By providing tools and education to the development community and internal staff the hope is to further perpetuate the "community ethic" therefore realizing the Vision.

Strategic Goals:

- By the end of 2018 finalize the Gray to Green Development Document and share it with stakeholders and the Public.
- Apply for funding to continue moving the needle on creating opportunity for Green Development practices to be used in Winter Haven.

Floating Treatment Wetland:

Summary:

It has been established that emergent vegetation acts as a temporary nutrient sink within an aquatic environment. Additionally, the physical removal of vegetation is necessary to eliminate the eventual nutrient source that arises as plants decompose in a waterbody. Unfortunately, the time and effort required to extract this vegetation becomes progressively expensive and impractical in larger volumes. Implementing floating treatment wetlands (FTWs) is a solution for the assimilation of nutrients by macrophytes (plants), bacterial conversion of nitrogen into atmospheric form, and relatively simple plant removal. Figure 3-4 depicts a diagram of a floating wetland. Instead of planting emergent aquatic vegetation in the substrates of lake shores, wetlands, and stormwater detention ponds, plants can be placed on floating foam rafts and allowed to grow and assimilate nutrients without rooting into aquatic sediments. After a defined period of time (typically 3, 6, or 12 month increments), these plants can be removed with considerably less effort than if they were planted traditionally.

A study performed by the University of Central Florida's Stormwater Management Academy in 2012 sought to evaluate the efficacy of FTWs in the removal of nutrients from stormwater detention ponds. Using rafts covering 5% of pond surface area, the floating wetland treatment reduced total nitrogen (TN) by 16% and total phosphorus (TP) by 44% on average as well as significantly inhibited the growth the algae and duckweed in the stormwater ponds[10]. The removal efficiencies determined by this study also prompted the FDEP to grant a 12% credit to the reduction of TN and TP in the calculation of TMDLs for a waterbody where a FTW is used[10]. Due to this information, the City of Winter Haven plans to implement a trial FTW in a stormwater pond that discharges to Lake Martha. This trial period is to begin in 2017 at the start of the Florida rainy season in late Spring and conclude when precipitation rates drop off in Fall. The data collected will determine the efficacy of expanding the use of FTWs to more ponds in the Winter Haven area.

Public Benefit:

This project has a fourfold potential for benefits. The first being potential for reduction in the stormwater pond where it is deployed helping to stabilize that system by limiting swings in nutrient and oxygen concentrations that lead to undesirable conditions. Second is an opportunity to provide desirable aquatic vegetation to lake front homeowners at no cost. Third is an opportunity to communicate with the public about why such a management strategy is effective and how the same theories apply to lakes. Lastly, is a learning opportunity for the City to determine the worthwhileness of this pilot project and the value in expansion.

Support of Mission, Purpose, and Vision:

This pilot project is an implantation of the Mission as it is derived from an understanding of the "social, economic, and ecological systems" that govern the existing stormwater pond and the impacts that can be felt by the community and the adjacent lake. Currently this pond can reach conditions deemed undesirable by the local stakeholders, this project is designed to alleviate those conditions restoring "natural resources the community can be proud of" as is part of the Division's Purpose. By engaging in this pilot project the City will deepen it's understanding of how local systems function further supporting its position as "the premier knowledge base for local natural resources" and creating an opportunity to engage the public in conversations about management strategy which works to achieve the Vision.

Strategic Goals:

- By November 2018, host a public education & plant giveaway event
- By end of 2018, restock the FTW with new aquatic plant seedlings
- Pending study results, determine the efficacy of expanding project to other sites
- By end of 2018 draft a report detailing the effectiveness of the FTW in reducing nutrient concentrations

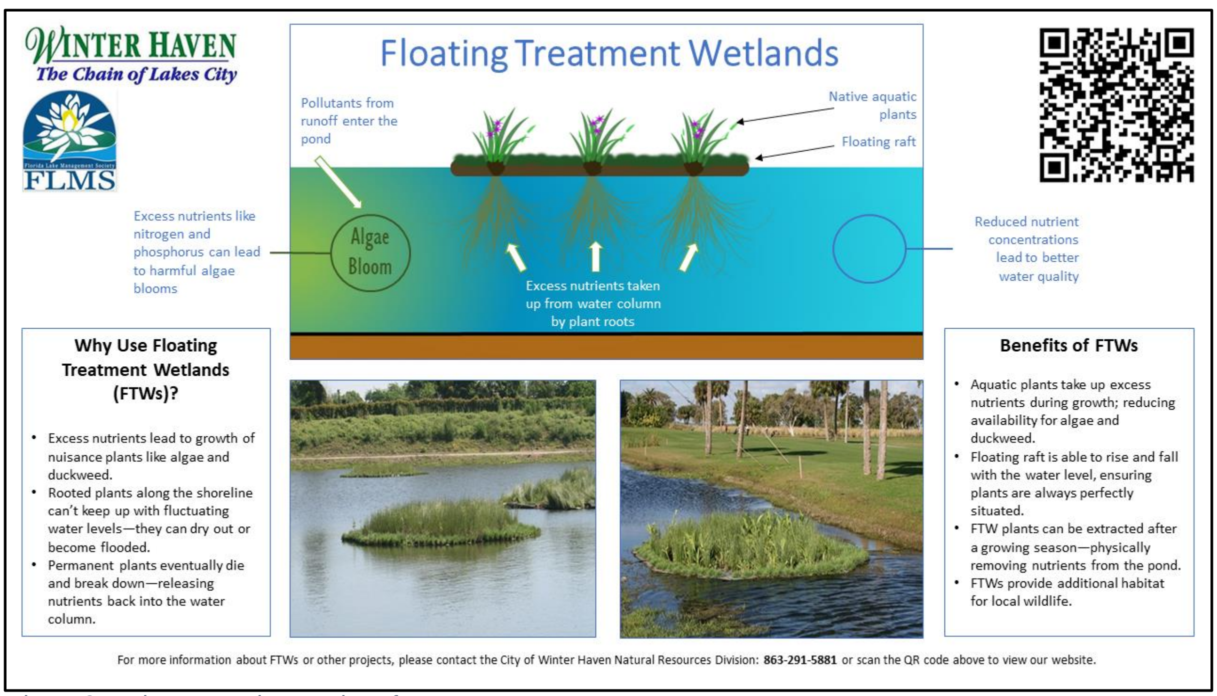

Figure 3-4 Diagram and examples of FTW processes

3.2 In-Lake Initiatives

Aquatic Vegetation Monitoring:

Summary:

The importance of aquatic vegetation on the health of a waterbody has been discussed previously in this report, however the City's role in managing the aquatic plant community must be demonstrated as well. Winter Haven's Natural Resources Division is currently engaged in a long-term data collection project that involves sonar mapping each navigable lake to determine macrophyte abundance while simultaneously collecting samples of each lake's vegetative community in order to ascertain species diversity and evenness. The aim is to collect individual lake data at least once per year to monitor annual and possibly even seasonal changes in the species composition and density of vegetative communities.

The Aquatic Vegetation Monitoring (AVM) process starts with the creation of transect grids with sampling points in ArcGIS (Figure 3-5). Once created, transects and sampling points are uploaded to a sonar/GPS receiver aboard a City vessel. Sonar, which is an acronym for SOund Navigation And Ranging, uses sonic pulses to determine distance to objects underwater. A receiver measures sediment density and depth to the bottom as well as the percentage of the water column occupied by aquatic flora (biovolume). This sonar data is logged as City employees drive along the transect lines while simultaneously collecting vegetation samples at each point, until the entire lake has been covered. Vegetation sampling provides information on species composition and density while the sonar data is used to create a heat-map representation of biological volume—indicating areas of high or low aquatic vegetation abundance. Overlaying the species data on top of the biovolume heat-map creates a graphic that allows users to determine areas that require management such as the elimination of invasive species. A map of Lake Rochelle biovolume and species frequency has been created as an example (Figure 3-6). Furthermore, by making this data available to other agencies, the City helps foster cooperation and incentivize future assistance and funding. This project, for example, provides assistance to the Polk County Natural Resources Division by expediting the process of evaluating areas that require management of invasive species via herbicide application.

Public Benefit:

Aquatic vegetation is a significant component of lake health and understanding it provides multiple benefits to the community. Most visible is the early detection and early response to invasive species identified in the summary. But major changes in plant communities are an early indicator that something negative may be happening in a lake and can serve as a red flag for a pending lake issue allowing time for corrective action to be taken. By understanding the vegetative community staff can help guide the management of species on local lakes towards the types of communities that create stability and health in lake systems.

Support of Mission, Purpose, and Vision:

This effort supports the Mission by developing a “sound understanding of social, economic, and ecological systems” which enables the Division to serve its Purpose and “Balance the need of diverse user groups while sustaining natural resources”. This is also in fulfillment of the Vision by establishing the City as “the premier knowledge base for local natural resources” and ensuring the community is represented at the table for discussions about management of the resource.

Strategic Goals:

- By the end of 2018, prioritize and complete annual vegetation surveys.
- By the end of 2018 develop sampling protocol and surveying schedule with Aquatic Vegetation Working Group to reduce surveying redundancies and improve efficiency.

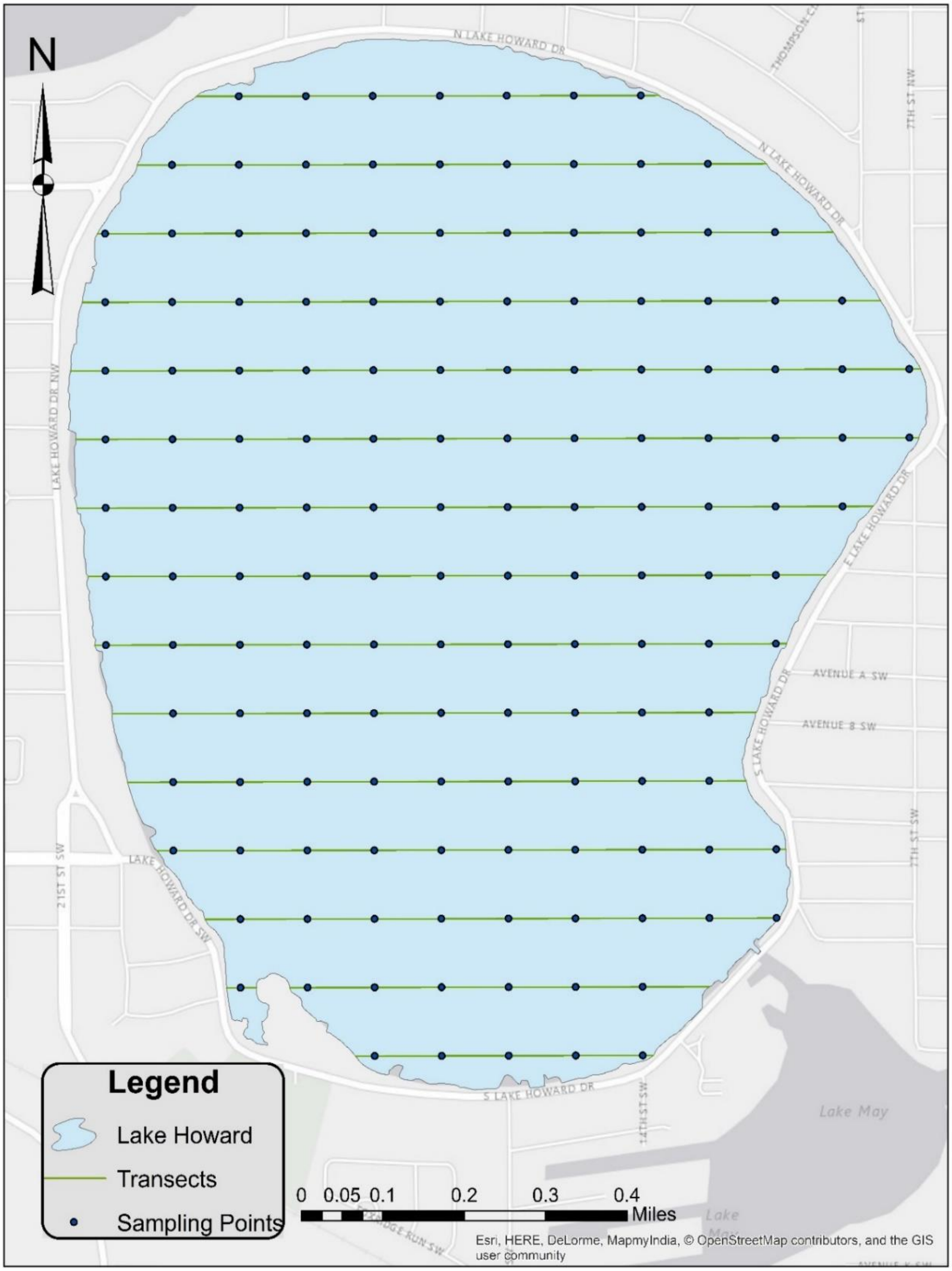

Figure 3-5 Lake Howard transects and sampling points created in ArcGIS

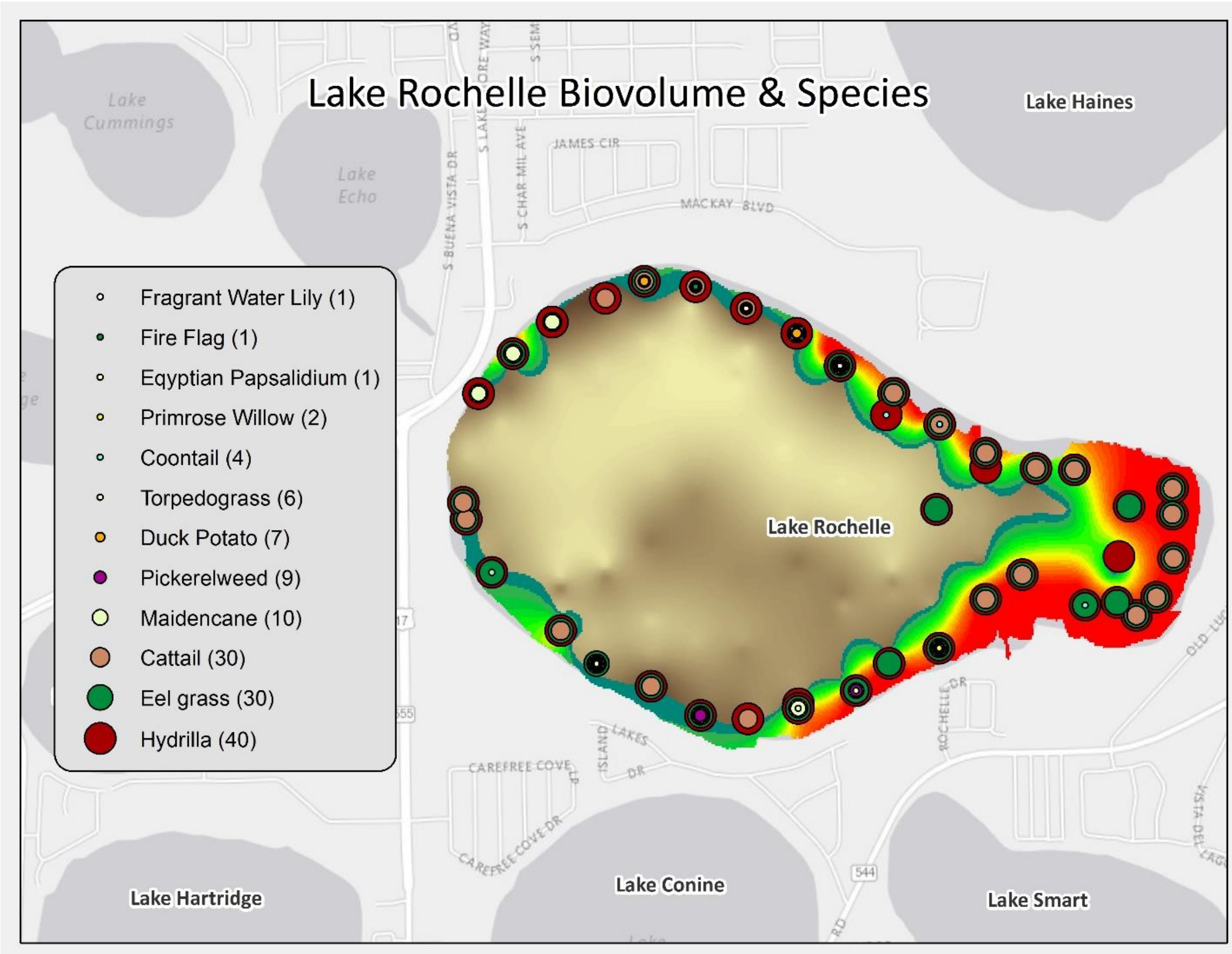

Figure 3-6 Lake Rochelle biovolume heat-map including species identification and density

Hydrologic Monitoring:

Summary:

Hydrologic monitoring assesses the processes relating to water quantity in the area and is critical in understanding the relationships amongst rainfall, surface level changes, and groundwater interactions. Changes in water quality often share a strong relationship with hydrologic fluctuations as well.

The City is currently engaged in monitoring programs that track rainfall accumulation, lake surface level and groundwater fluctuations. Utilizing radar stations and a growing network of atmospheric sensors, the Natural Resources Division collects precipitation data to understand how much water enters the Winter Haven area. Additionally, the observation of surface level and groundwater fluctuations at several Environmental Monitoring Protocol (EMP) sites provide insight into the effects of rainfall and municipal groundwater usage on the numerous waterbodies across the City. All of these metrics are integral in the calculation of the water budget—ensuring the most efficient use of our limited supply.

Public Benefit:

Surface water hydrology is a critical element of water quality management as can be seen by the relationships to water level fluctuations in this report. Understanding this element is necessary to design effective management strategy. This information is immediately useful for things like assessing flood potential prior to a hurricane, but also will prove invaluable for posterity managing the resource.

Support of Mission, Purpose, and Vision:

This activity directly supports the Mission by developing “a sound understanding of social, economic, and ecological systems”. Due to the unique nature of the local system, water levels are critical not just for water quality, but also for navigation through the Chain of Lakes. Navigability is of the utmost important to the “diverse user groups” in the Purpose, and by understanding how the local hydrology works the City is able to be the “premier knowledge base”, mentioned in the Vision, that can drive decision making about management of the resource.

Strategic Goals:

- By the August 2018 overhaul existing system for monitoring surface water hydrology.
- By the start of the 2018 rainy season increase coverage of rainfall monitoring stations to better understand localized impacts of rainfall.
- By FY18-19 budget preparations have plan for network expansion laid out.

Nutrient Budgeting:

Summary:

A nutrient budget utilizes external pollutant load modelling data, internal load modelling data, as well as biovolume and species composition data to estimate the amount of nutrients entering and leaving a lake system. External loading, briefly discussed earlier in this report, includes stormwater and surface runoff, atmospheric deposition of nitrogen and phosphorus, and groundwater seepage. Total Maximum Daily Loads (TMDLs) are calculated by modelling for these external inputs. Internal loading accounts for the nutrient cycling or flux from lake sediments and is calculated by evaluating the physical and chemical properties of these sediments. The biological component of a nutrient budget, which will be explained in greater detail in this section, is determined by calculating the amount of nutrients interred by lake aquatic vegetation.

The vegetative portion of the nutrient budget is calculated by linking the average nutrient concentrations of plant tissues with species density values obtained during the vegetative sampling process explained previously. Plant tissue nutrient concentrations, which are determined through laboratory testing, vary from species to species. By virtue of this, average tissue concentrations per unit of dry mass need to be determined for each species found in the lakes studied. In order to relate the biomass variable with sample density, the average dry weight of each density rank is recorded for every species encountered. This process allows scientists to assign a nutrient concentration value to each sample point for a given waterbody. Extrapolating the point data to relate to the biovolume component is the next logical step in this process—allowing the City to estimate the nutrient content of aquatic vegetation in each lake on an annual or seasonal basis.

Public Benefit:

Nutrients bound in vegetation account for a significant portion of nutrient in lakes and understanding this content enables better management decisions. For example if a lake has a significant population of *Potamogeton Illinoensis* knowing it will die back and release its nutrients once it gets cold. A management plan could be devised to remove a known volume of Phosphorus prior to the first cold snap of the year. There is also potential to receive management credit with State and Federal agencies using this type of approach. This is one example of how this data can be used to drive management strategy.

Support of Mission, Purpose, and Vision:

This effort supports the Mission by developing a “sound understanding of social, economic, and ecological systems” which enables the Division to serve its Purpose and “Balance the need of diverse user groups while sustaining natural resources”. This is also in fulfillment of the Vision by establishing the City as “the premier knowledge base for local natural resources” and ensuring the community is represented at the table for discussions about management of the resource.

Strategic Goals:

- By the start of rainy season 2018 develop a plan for creating nutrient budgets for Priority 1 Lakes

Figures

Tables

References

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