WATER QUALITY STANDARDS AND CLASSIFICATION OF SURFACE WATERS

The Federal Clean Water Act (CWA) is the cornerstone of surface water quality protection of the United States and requires that surface waters of each state be classified according to designated uses. Florida has six classes with associated designated uses, which are arranged in order of degree of protection required:

Class I – Potable Water Supplies

Class II – Shellfish Propagation or Harvesting

Class III – Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife (majority of surface waters fall under this category)

Class III (Limited) – Fish Consumption; Recreation or Limited Recreation; and/or Propagation and Maintenance of a Limited Population of Fish and Wildlife

Class IV – Agricultural Water Supplies

Class V – Navigation, Utility and Industrial Use

Each class has scientifically established thresholds for contaminants and ecological conditions to assure that public health and aquatic life are protected. If the designated use of surface water is not being met and maintained, the cause of the water quality degradation ("impairment") must be identified and fixed. The State programs established to identify problems and restore water quality are Total Maximum Daily Loads (TMDLs) and Basin Management Action Plans (BMAPs).

METHODOLOGIES AND PARAMETERS

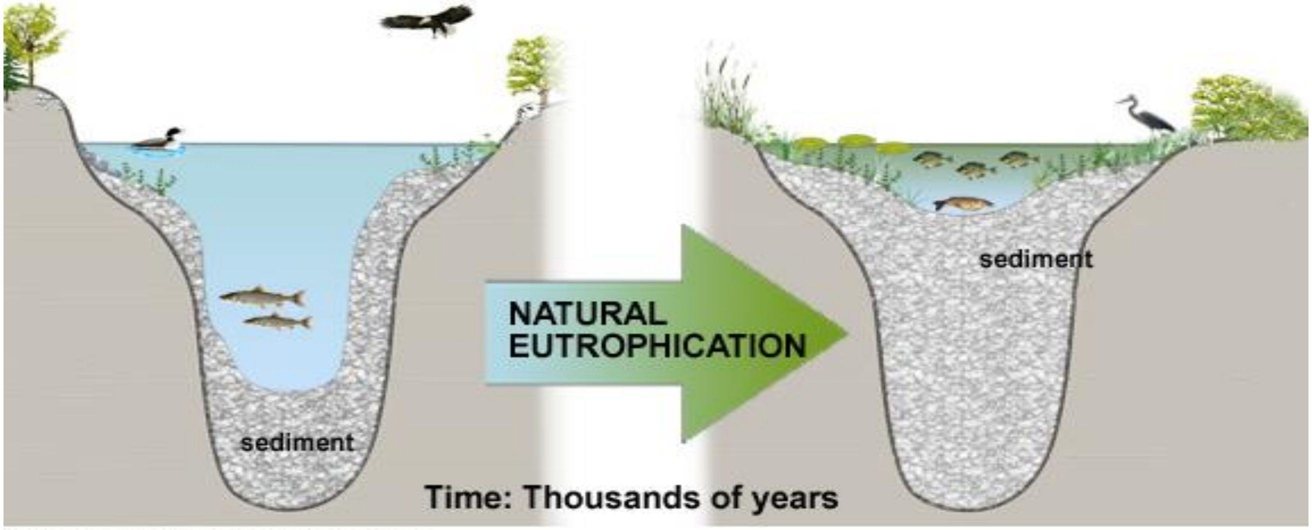
Utilizing a holistic approach, combinations of chemical and biological parameters are used to evaluate the health of our waterbodies since a single indicator is inadequate for proper evaluation. The evaluation parameters and goals are explained by the following:

Eutrophication, Biological Productivity and Nutrients

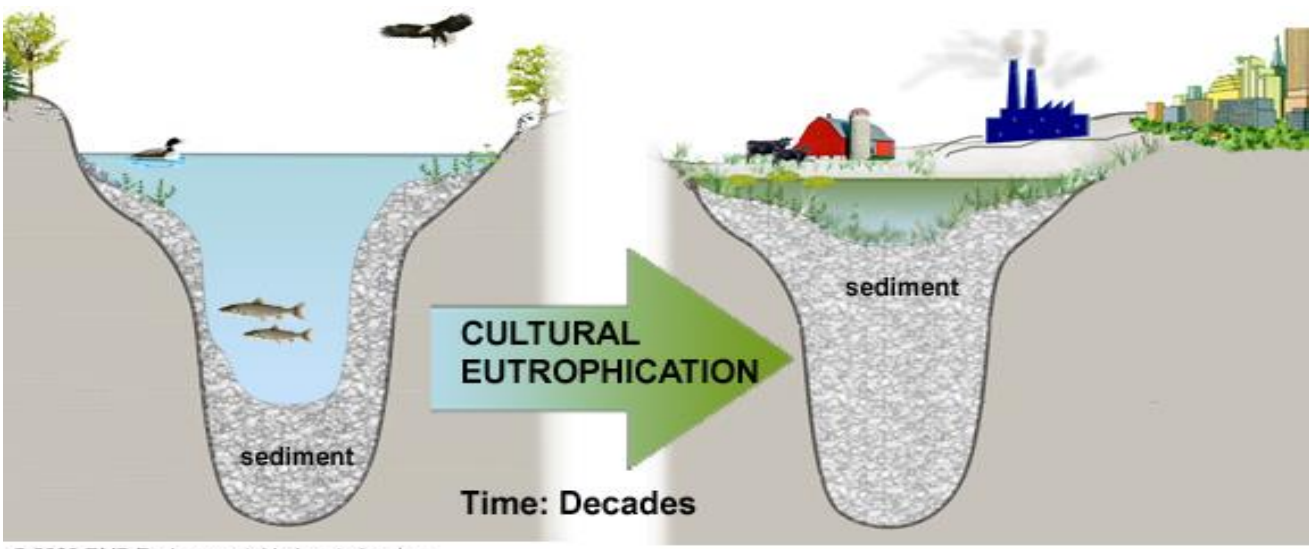
For Florida lakes, three interrelated measurements are often used as a starting point to evaluate lake health. These measurements are: the level of eutrophication, biological productivity and nutrients.

Eutrophication

Natural eutrophication is a gradual process by which lakes age and become more productive as the lake builds up concentrations of plant nutrients. This occurs when production and consumption within the lake become unbalanced and the lake slowly becomes overladen with nutrients. While not rare in nature, natural eutrophication normally takes thousands of years to progress.



Cultural (or anthropogenic) eutrophication is caused by human activities accelerating eutrophication by increasing the rate at which nutrients enter the water. Increased levels of nutrients result in rapid growth of both vascular plants and algae. These increased plants and algae then increase oxygen output during the day, but utilize oxygen at night. Therefore, if enough plants and algae are in the lake, oxygen levels can be decreased to levels that will kill fish and other aquatic animals. As algae and plants die, they are then decomposed by bacteria which release a portion of nutrients into the water. These bacteria also utilize oxygen in the water, which further depresses oxygen levels in or directly above the sediment. As part of the decomposition process, plants and algae sink to the bottom of the lake and become part of the sediment. Eventually the lake starts to fill with sediment and in extreme cases will completely disappear.



Biological Productivity

Biological productivity is defined as the ability of a waterbody to support aquatic life. The amount of biological productivity (algae, vascular plants, fish, etc.) that a waterbody can produce and sustain is defined as the trophic state. Waterbodies are generally classified into four groups according to their level of biological productivity and are as follows:

a) Oligotrophic – Low nutrient content. Oligotrophic lakes typically have less aquatic vascular plants and algae and have high water clarity. Low levels of fish and wildlife are supported.
b) Mesotrophic – Moderate nutrient content. Mesotrophic lakes are capable of producing and supporting moderate levels of macrophytes, fish and wildlife.
c) Eutrophic – High nutrient content. Eutrophic lakes have high biological productivity and typically support large populations of fish and wildlife.
d) Hypereutrophic – Extremely high nutrient content. Hypereutrophic lakes can support abundant populations of algae, macrophytes, fish and wildlife. Typically, the bottom of these waterbodies will have thick layers of organic sediments as the decaying plant and/or algal debris accumulates. Oxygen depletion due to algal blooms/decaying plant material may be a common cause of fish kills in these waterbodies.

Nutrients

Nationally, nutrient pollution is directly linked to 20% of impaired river and stream miles, 22% of impaired lake acres and 8% of impaired bay and estuarine square miles. While nitrogen and phosphorus are essential for plant growth, excessive amounts entering waterbodies can lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat.

Phosphorus

Phosphorus is required by both plants and animals, and commonly is the first element to limit biological productivity. When phosphorus is supplied, plant growth is stimulated. In rivers, streams and lakes, phosphorus can cause problems by stimulating excess plant growth and reducing the quality of the water. Under certain conditions, excess phosphorus can contribute to excessive aquatic plant growth, algal blooms, low dissolved oxygen levels, fish kills and loss of biodiversity. Nonpoint source pollution, such as excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas, is a major source of phosphorus to surface waters in the United States. A large proportion of phosphorus in freshwater occurs as organic phosphates and cellular constituents in the biota or is adsorbed to inorganic and dead particulate matter. Orthophosphate (PO_4^{3-}) is the soluble form that can be directly utilized by algae and aquatic plants.

Nitrogen

Like phosphorus, nitrogen is often considered a limiting nutrient in the flora and fauna of our freshwater ecosystems. Although nitrogen is the most abundant element in the atmosphere, nitrogen from the air cannot be used by plants until it is chemically transformed or fixed into ammonium or nitrate compounds that plants can metabolize. The forms of nitrogen considered most bioavailable are nitrate (NO_3^-) and ionized ammonia (NH_4^+). Elevated nitrogen levels can have serious effects on aquatic ecosystems. Due to increases of fertilizer use, improper disposal of sewage, burning of fossil fuels and land clearing/deforestation, the amount of nitrogen available for uptake has increased substantially. In the case of waterbodies, excess nitrogen (like excess phosphorus) can contribute to excessive aquatic plant growth, algal blooms, low dissolved oxygen levels, fish kills and loss of biodiversity.

Chlorophyll

Chlorophyll is a green pigment that allows plants to convert sunlight into organic compounds during photosynthesis, and its abundance is a good indicator of the amount of algae in lakes, rivers and streams. Chlorophyll levels can be an effective measure of trophic status, are potential indicators of maximum photosynthetic rates and are a commonly used measure of water quality. High levels often indicate poor water quality and low levels often suggest good water quality conditions. "Chlorophyll-*a*" is the predominant type of chlorophyll found in algae and cyanobacteria (blue-green algae) and is the form of chlorophyll that is most often analyzed in water quality tests.

Limiting Nutrient

A limiting nutrient is a nutrient that influences plant growth but is available in quantities smaller than needed for algae and aquatic plants to increase their abundance. Once the limiting nutrient is exhausted, algae stop growing. If more of the limiting nutrient is added, larger algal populations will result until the nutrient is again exhausted or growth is stopped by some other limiting factor. For example, when phosphorus is the limiting nutrient, the addition of phosphorus to a waterbody will encourage the growth of algae and aquatic plants.

In most Florida lakes, the limiting nutrient is believed to be phosphorus. However, in watersheds with an abundance of phosphorus deposits in the soil, as in Leon County, nitrogen can be the limiting nutrient.

The total nitrogen/total phosphorus (TN/TP) ratio is used to determine nutrient limitation in Florida waters. Florida waterbodies are divided into three groups:

- When the TN/TP ratio is less than 10, a waterbody is nitrogen-limited;
- When the TN/TP ratio is between 10 and 30, either nitrogen or phosphorus could be limiting;
- When the TN/TP ratio is greater than 30, a waterbody is considered phosphorus-limited.

Numeric Nutrient Criteria

Numeric nutrient criteria are based on the EPA nutrient standard narrative, which states that: "in no case shall nutrient concentrations of a body of water be altered as to cause an imbalance in natural populations of flora and fauna." After a lawsuit in 2009, the FDEP developed and implemented Florida's numeric interpretation to the narrative nutrient criterion, establishing that protected waterbodies include: tidally influenced streams and estuaries, non-perennial streams, and actively maintained conveyances, such as a canals or ditches.

Numeric Interpretation of the Narrative Nutrient Criterion

Site specific numeric interpretations established by the FDEP shall be the primary interpretation of the Narrative Nutrient Criteria. Primary site specific interpretations include:

1. Total Maximum Daily Loads that interpret the narrative water quality criterion for nutrients
2. Site specific alternative criteria (SSAC) for one or more nutrients or nutrient response variables
3. Other site specific interpretations for one or more nutrients or nutrient response variables that are formally established by rule or order by FDEP.

In lieu of site specific criteria, the following criteria can be used.

Florida Lakes

The following table illustrates chlorophyll-*a*, total nitrogen (TN) and total phosphorus (TP) threshold concentration levels in Florida's Lakes. Based on geometric means, these levels are not to be exceeded more than once in any three year calendar period.

Lake Color[a] and Alkalinity	**Chl-*a* (µg/L)[b]**	**Minimum calculated numeric interpretation**		**Maximum calculated numeric interpretation**	
		TP (mg/L)	**TN (mg/L)**	**TP (mg/L)**	**TN (mg/L)**
Colored Lakes[c]	20	0.05	1.27	0.16	2.23
Clear Lakes, High Alkalinity[d]	20	0.03	1.05	0.09	1.91
Clear Lakes, Low Alkalinity[e]	6	0.01	0.51	0.03	0.93

[a] Platinum Cobalt Units (PCU) assessed as true color free from turbidity
[b]Chlorophyll-*a* is defined as corrected chlorophyll, or the concentration of chlorophyll-*a* remaining after the chlorophyll degradation product, phaeophytin-*a*, has been subtracted from the uncorrected chlorophyll-*a* measurement.
[c]Long-term Color > 40 Platinum Cobalt Units (PCU)
[d]Long-term Color $\leq$ 40 Platinum Cobalt Units (PCU) and Alkalinity $\geq$ 20 mg/L $CaCO_3$
[e]Long-term Color $\leq$ 40 PCU and Alkalinity $\leq$ 20 mg/L $CaCO_3$

Florida Streams

Biological information can be used to interpret criteria in combination with nutrient thresholds. The narrative criteria can be interpreted as being achieved in a stream where information on chlorophyll-*a* levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora or fauna, and either:

1. The average score of at least two temporally independent Stream Condition Index samples is 40 or higher, with neither of the two most recent scores less than 35.
2. The nutrient thresholds in the following table are achieved.

Total Phosphorus Nutrient Threshold	**Total Nitrogen Nutrient Threshold**
0.18 mg/L	1.03 mg/L

Based on geometric means, these levels for eastern panhandle streams are not to be exceeded more than once in any three calendar year period.

Other Parameters:

Other important parameters that are used to evaluate the health of our area's lakes, streams, and rivers are explained below:

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen present in the water. It is measured in terms of milligrams per liter (mg/L). Oxygen gets into water by diffusion from the surrounding air, physical aeration (rapid movement), and as a byproduct of photosynthesis. Because photosynthesis requires light, it can only occur during daylight hours and is offset by the constant loss of oxygen used during normal respiration of living organisms and the decomposition of dead plant material and other organisms. This can cause the DO concentration to steadily decline at night. The DO concentration is lowest just before dawn when photosynthesis resumes. Other influences on DO include the weather, depth of water, and the temperature.

Pollution can affect DO levels by contributing oxygen-demanding organic matter (sewage, lawn clippings, soils from streambank and lakeshore erosion, and from agricultural runoff) or by contributing nutrients that stimulate growth of bacteria and algae. As these materials enter a waterbody, bacterial growth is stimulated and the population increases rapidly, consuming the available oxygen as it does so.

Dissolved Oxygen Percent Saturation

Oxygen saturation is the relative measure of oxygen that is dissolved in water.

High dissolved gas concentrations in water (>110%) can be caused by excess oxygen production by aquatic plants (enhanced by excess nutrients associated with pollution), solar heating, hydroelectric and impoundment dams and can be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer from Gas Bubble Disease (GBD). This disease is caused when supersaturated gases in the water escape from the water into the body fluids of the fish (effects that are similar to the "bends" that scuba divers sometimes experience). Aquatic invertebrates are also affected by gas bubble disease but at DO levels higher than those lethal to fish.

Biological Oxygen Demand

Biological oxygen demand (BOD) directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream by microbial organisms. This means less oxygen is available to higher forms of aquatic life. Lower dissolved oxygen levels mean higher level aquatic organisms (fishes) become stressed or die. Sources of increased BOD include: fertilizers, wastewater, feedlots, dead plants and animals, and stormwater runoff.

Specific Conductance

Specific conductance is a measure of how well water can conduct an electrical current and is measured as µmhos/cm or µSiemen/cm. A higher value of conductance is the result of increased dissolved salts (free ions) in the water allowing the water to become a better electrical conductor. Because human waste, fertilizers, and runoff from feedlots and roads contain salts, specific conductance can be used as an indicator of waterbody contamination.

pH

The pH value is the measure of the acidity or alkalinity of a solution. The measurement (measured in SU or Standard Units) ranges from 0 (acidic) to 14 (alkaline) with 7 being neutral. The pH of a particular waterbody is often influenced by basin location and the vegetation characteristics of that basin. For example, oligotrophic cypress rimmed lakes will tend to have lower pH values than other lakes in the same region because when cypress needles fall and decay in the water they make the water more acidic. However, highly eutrophic lakes (even cypress rimmed lakes) will have higher pH values due to algae reducing carbon dioxide in the water column. Changes in pH can cause problems because plants and animals are adapted to survive in water at a certain pH. When pH is raised or lowered, the organisms in and around the water may become stressed or die. The pH of the water also affects the solubility and thus the bioavailability of other substances. As the pH falls, water becomes more acidic and many substances become more soluble and available for absorption.

Alkalinity

Alkalinity is a measure of the buffering capacity of the carbonate system in water or the capacity of water to neutralize acids. Alkalinity in water results from any dissolved compounds, usually weak acid anions that can accept and neutralize protons. Carbon dioxide (CO_2) is quite soluble and relatively abundant in water and carbonates are common as primary minerals over much of the earth; therefore, the alkalinity of most freshwaters is mainly made up of bicarbonates and carbonates. Alkalinity is important for aquatic life because it protects or buffers against rapid pH changes. Buffering capacity resistance to changes in pH is increased when alkalinity levels are higher. The presence of buffering materials in water also helps to neutralize acids as they get added to the water through rainfall or discharges.

Color

Color in natural water may be caused by grains of rock forming minerals such as quartz, clay mineral particles, detrital organic material, tannins, virus particles, and living cells of bacteria and algae. Water color is usually the direct result of the upstream watershed. In aquatic environments with high light transparency (clear water), the phytoplankton populations are strongly correlated to the supply of nutrients; but in opaque or blackwater systems, light availability can be a major limiting factor for primary production.

Bacteriological

Indicator bacteria are used to detect the probable presence of pathogenic bacteria associated with fecal pollution. These bacteria normally do not cause illness, but their presence can indicate possible fecal contamination and/or disease-causing pathogens. Fecal coliforms, a subset of the total coliform group, have historically been used to determine if a waterbody has been contaminated. These bacteria often (but not always) live in the lower intestines of warm-blooded animals, including wildlife, farm animals, pets, and humans. In addition to collecting samples for fecal coliform analysis, Leon County now collects samples for *E. coli* analysis. *E. coli* is one subgroup of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. EPA recommends *E. coli* as the best indicator of health risk from water contact in recreational waters.

Sources of fecal contamination can include: direct deposition by wildlife or pets, wastewater treatment outfalls, septic tank runoff, or diffuse sources such as runoff from fields where livestock waste has been applied.

More information regarding fecal coliform bacteria can be found at the EPA's Water: Monitoring and Assessment – Fecal Bacteria website.

Temperature

Temperature impacts both the chemical and biological characteristics of surface water. Plant and animal metabolism, growth, emergence, and reproduction are directly related to temperature, whereas food availability (both quantity and quality) may be indirectly related through associated microbial activity. Temperature changes as the result of human activities can be detrimental to the environment. Thermal pollution is the introduction of water that is significantly warmer or cooler than the body of water into which it flows. Thermal pollution is typically associated with manufacturing or power plants. These industries discharge hot water that has been used to cool equipment directly into streams.

As many aquatic organisms are directly affected by temperature, this particular environmental impact is significant. Warm water is less capable of holding dissolved oxygen and the problem is magnified by the fact that biological activity increases as water temperature rises, increasing oxygen demand. Decreases in oxygen levels and increases in metabolic activity of the aquatic animals can alter ecosystems by stressing animals and increasing the probability of disease; causing food shortages (increased metabolism means more food is needed); killing juvenile fish that are more affected by increased water temperature, and increasing the probability of large scale fish kills.

Turbidity

Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light - the higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid includes clay, silt, finely divided organic compounds, plankton, and other microscopic organisms. Excessive levels of turbidity can have numerous effects on water quality and the biological activities of fish and wildlife. Turbidity can inhibit photosynthesis, reducing aquatic plant and algae growth. Turbid water can reduce visibility for fish and other animals when seeking prey.

Total Suspended and Total Dissolved Solids

Total Suspended Solids (TSS) are solids in water than can be trapped by a filter (usually with a pore size of 0.45 micrometers) while Total Dissolved Solids (TDS) are solids that pass through the filter. TSS can include a variety of material, including silt, decaying plant and animal material, or sewage. High TSS can reduce water clarity and inhibit photosynthesis, increase water temperature, clog fish gills, affect predator-prey interactions, and smother eggs, aquatic insects, and their habitat. TDS can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions; a certain level of which is necessary for aquatic life.

Trace Elements

Leon County's NPDES program requires trace element analysis monitoring for several stations throughout the County. Trace elements naturally occur in very small amounts (few parts per million or less) in a given system. While a small amount of these elements are sometimes required for animal or plant life, many can be toxic at elevated levels.

Element	***Common Uses***	***Effects and Significance***
Arsenic	Alloys, pesticides, wood preservative, semiconductors	Toxic, possibly carcinogenic
Boron	Coal, detergents, used to make types of glass and ceramics	Essential trace element, toxic at higher levels, especially to arthropods, used to track sewer line and septic tank failures
Cadmium	Industrial discharge, mining waste, metal plating, plumbing	Replaces zinc biochemically, toxic to aquatic biota
Copper	Alloys, metal plating, electrical wiring, plumbing, mining	Essential trace element, toxic to vascular plants and algae at higher levels
Lead	Fuel additive, paint, bullets and shots, lead acid batteries	Toxicity (anemia, kidney disease, nervous system), harmful to wildlife
Nickel	Alloys, electroplating, batteries, coins, industrial, plumbing	Essential element in some animals, toxic at higher levels
Titanium	Alloys, used as a white pigment for toothpaste, soaps, makeup, paints, paper	Non-toxic, can be used to track sewer line and septic tank failures
Zinc	Alloy, industrial waste, metal plating, plumbing, batteries, deodorants	Essential element in many metalloenzymes, aids in wound healing, toxic to plants at higher levels