Crystal River/Kings Bay System

What is a Minimum Flow?

The minimum flow for a given watercourse is the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

—Section 373.042, Florida Statutes

A minimum flow is a rule used by the District to:

- **Protect springs, rivers and other flowing surface waters**
- **Review requests for groundwater and surface water withdrawal permits**
- **Plan for future water needs**

Minimum Flow Timeline

Time-Frame	Activity
2007–Ongoing	**Data Collection and analyses**
October 2016	**Draft minimum flow report presented to District Governing Board prior to peer review**
Oct.–Dec. 2016	**Peer review panel evaluated draft minimum flow report**
March 2017	**Peer review findings and staff response provided to Governing Board**
April 2017	**Revised draft minimum flow report posted online; public meeting being held to solicit public input**
May 23, 2017	**Final minimum flow report and request to initiate rulemaking/emergency rulemaking for minimum flow adoption to be presented to Governing Board**
May – June 2017	**Rulemaking processes**
July 1, 2017	**Minimum flow adoption required by State Law**

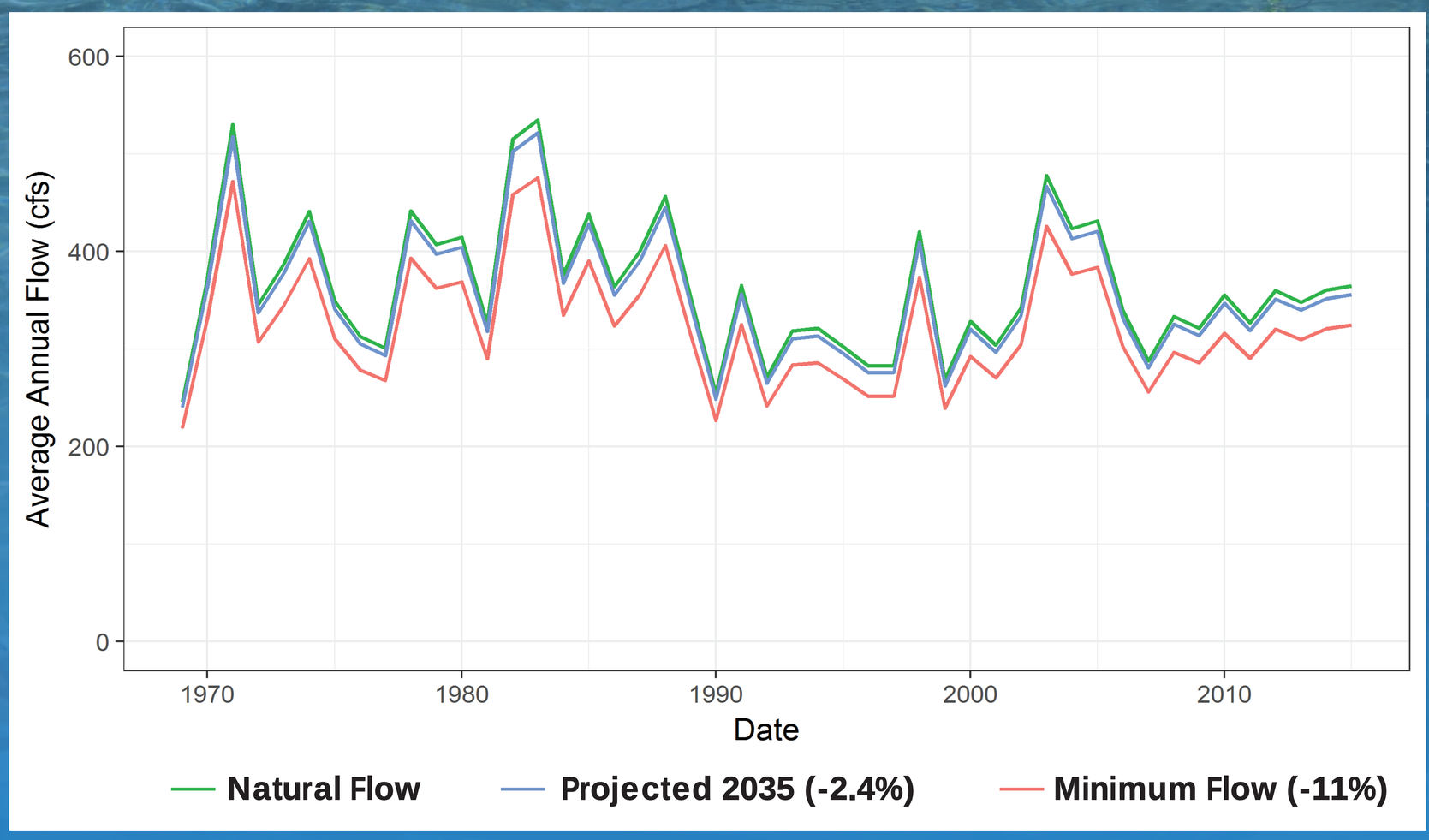
Minimum Flows and Levels (MFLs) Considerations

Environmental Values Protected When Developing Minimum Flows:

- **Recreation in and on the water**
- **Fish and wildlife habitats and the passage of fish**
- **Estuarine resources**
- **Transfer of detrital material**
- **Maintenance of freshwater storage and supply**
- **Aesthetic and scenic attributes**
- **Filtration/absorption of nutrients and other pollutants**
- **Sediment loads**
- **Water quality**
- **Navigation**

The proposed minimum flow protects even the most sensitive of these environmental values and 89 percent of the natural flow.

- **Green is the natural flow of Crystal River/ Kings Bay**
- **Blue is the flow based on projected water use in 2035**
- **Red is the flow at the proposed minimum flow**
- **The minimum flow mimics the natural flow**



Minimum Flows Protect the Most Sensitive Environmental Values

Low-Salinity Habitat

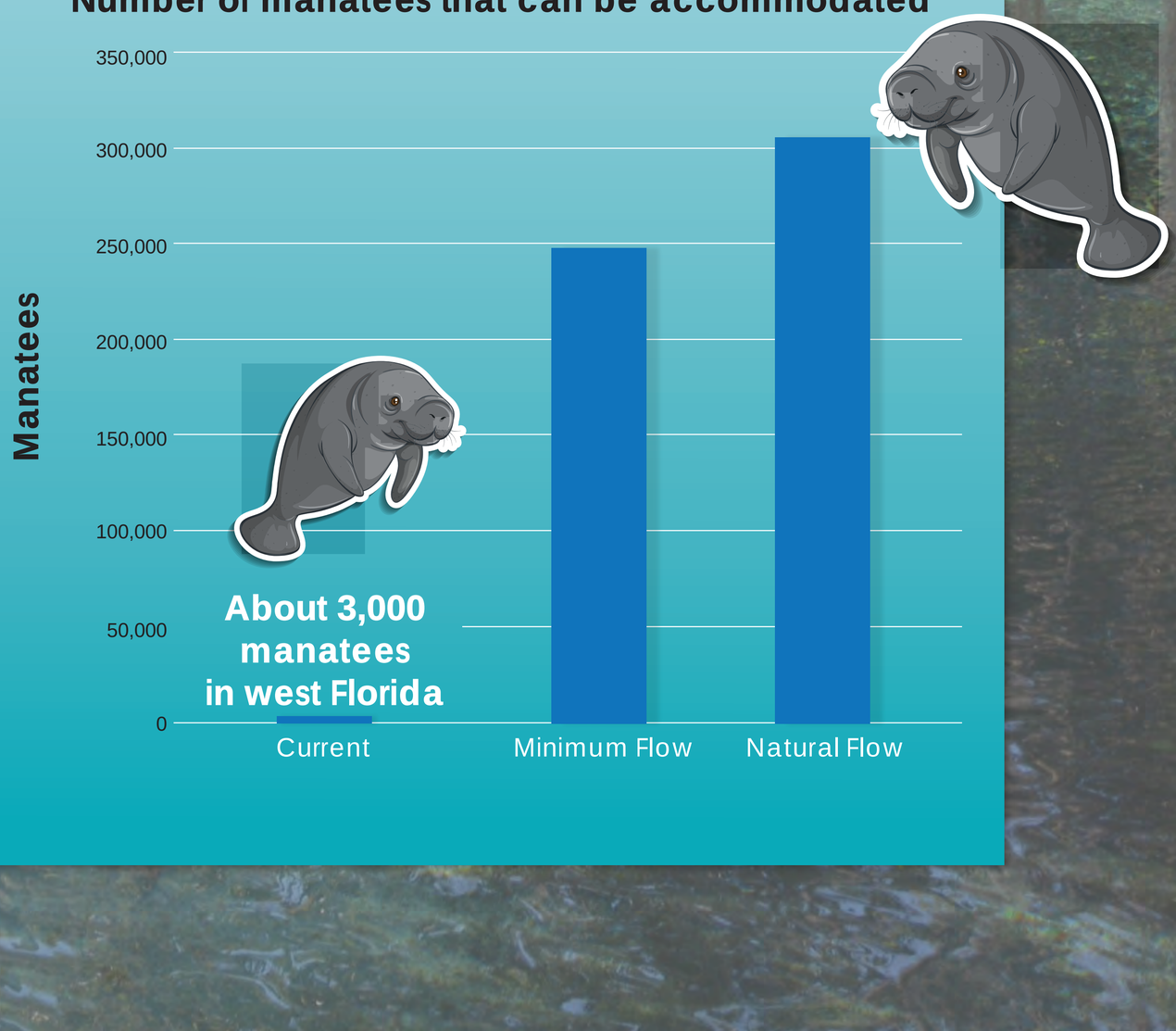
Fresh water flowing into estuaries is a primary concern in managing the health of an estuary. Among other things, the fresh water helps regulate salinity levels.

- **In Crystal River/Kings Bay, the most sensitive measure is low-salinity habitat**
- **Adequate inflow of fresh water is essential to maintain this estuarine ecosystem**
- **Greater than 11 percent reduction in flow is significantly harmful to low-salinity habitats**

Manatee Thermal Refuge

Warm spring water is important because manatee habitat can't fall below 59 F (15 C) for more than 4 hours.

- **Analysis was based on the coldest 4 hours in the 2009-2010 winter, which is the coldest winter in the last 69 years**
- **The proposed minimum flow preserves enough warm water for thousands more manatees than use Kings Bay as a thermal refuge**



Hydrodynamic Model For the Crystal River/Kings Bay System



Data used

To drive the model:

- **Measured water levels, salinities and temperatures at open boundaries**
- **Estimated groundwater discharges**
- **Wind speed and direction, solar radiation, air temperature, and air humidity near Inglis, Florida**

To calibrate/verify the model:

- **Measured water levels, salinities, and temperatures at the mouth of Kings Bay and Bagley Cove**
- **Measured discharge at Bagley Cove**

Simulation Periods:

Calibration Period: **12/2/2008 – 2/23/2010**

Verification Period: **4/24/2007 – 12/31/2008**

Scenario Run Period: **10/06/2006 – 11/31/2015**

Publications Related to Crystal River/Kings Bay Hydrodynamic Model:

XinJian Chen. 2014. Estimate Submarine Groundwater Discharge to Crystal River/Kings Bay in Florida with the Help of a Hydrodynamic Model. *J. Mar. Sci. Eng.*, 2:66 – 80; doi:10.3390/jmse2010066.

XinJian Chen. 2012. Simulating Hydrodynamics in a Spring-Fed Estuary Using a Three-Dimensional Unstructured Cartesian Grid Model. *Estuar. Coast. Shelf Sci.*,115: 246-259, doi:10.1016/j.ecss.2012.09.007.

XinJian Chen. 2011. A Three-Dimensional Hydrodynamic Model Using Unstructured Cartesian Grids. *Int. J. Numer. Methods Fluids,* 66:885-905, doi:10.1002/fld.2290.

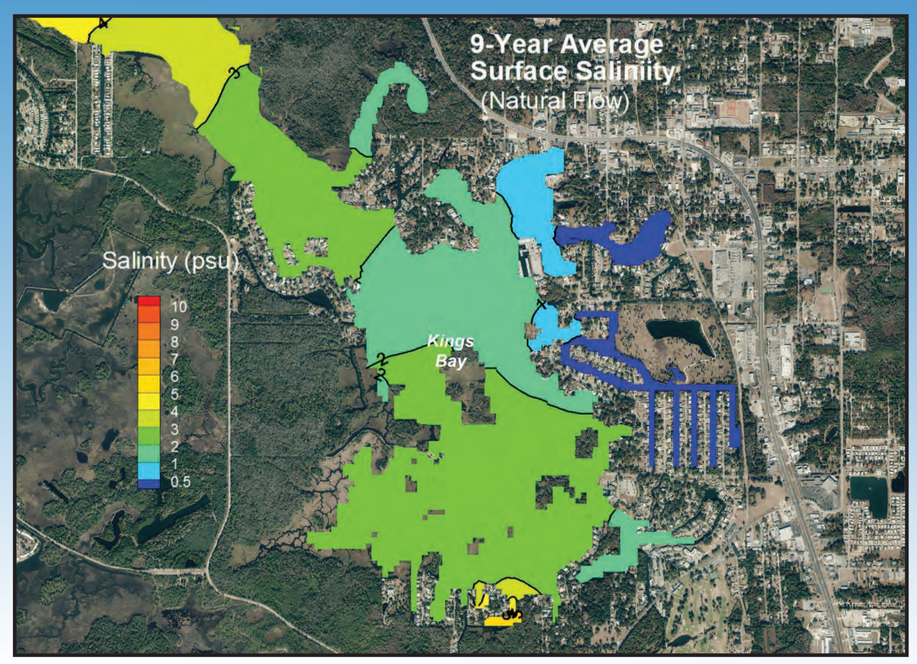
XinJian Chen. 2009. A Three-Dimensional Unstructured Cartesian Grid Model for Crystal River/Kings Bay in Southwest Florida. *ASCE Proc. Estuar. Coast. Modeling,* 11, 173:186.

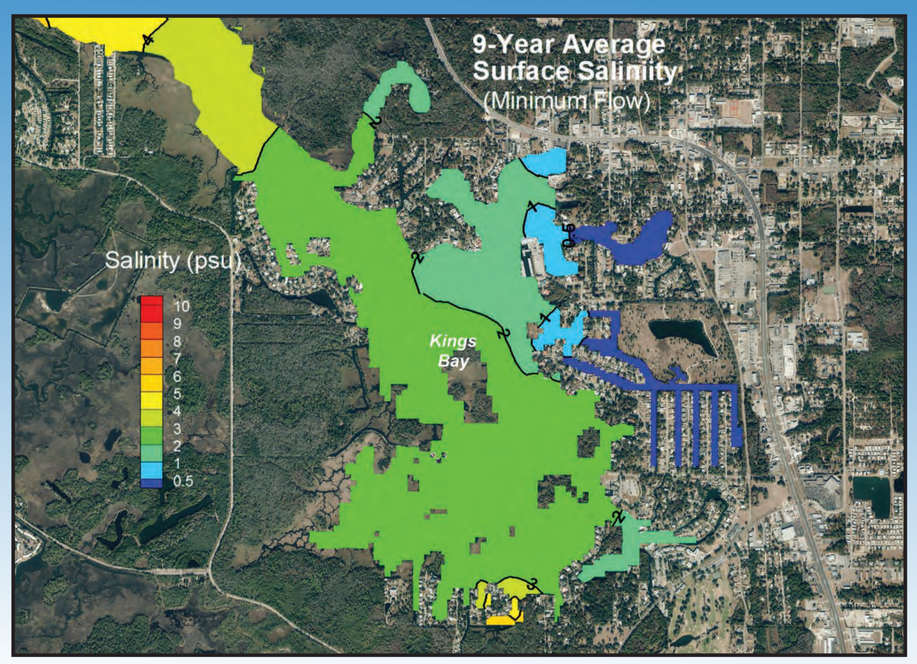
XinJian Chen. 2004. A Cartesian method for fitting the bathymetry and tracking the dynamic position of the shoreline in a three-dimensional, hydrodynamic model. *J. Comput. Phys.,* 42: 233-247.

XinJian Chen. 2003. A free-surface correction method for simulating shallow water flows. *J. Comput. Phys.,* 189: 557-578.

Minimum Flow Considerations

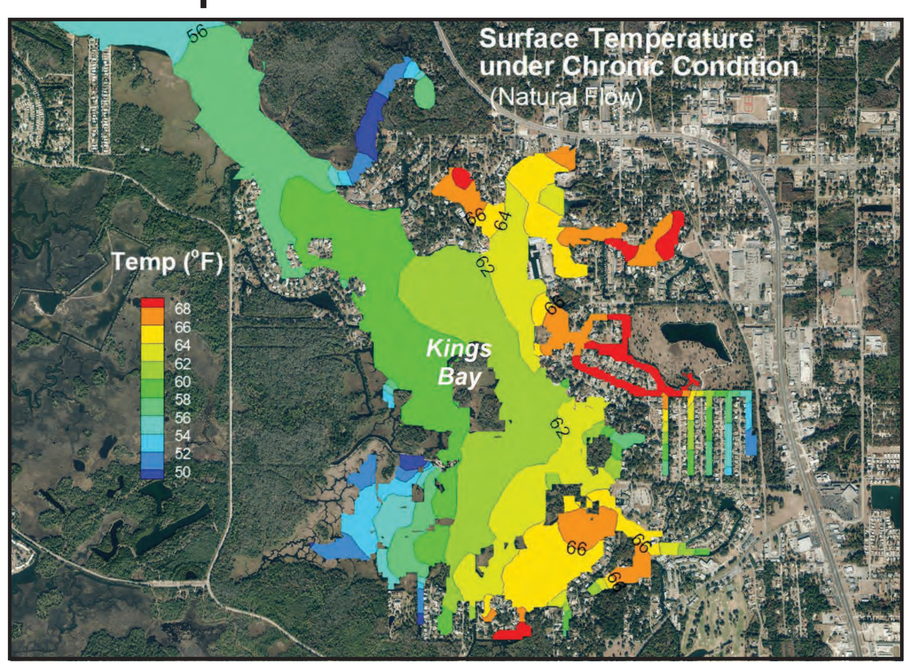
Comparison of surface salinity distributions for natural and proposed minimum flows

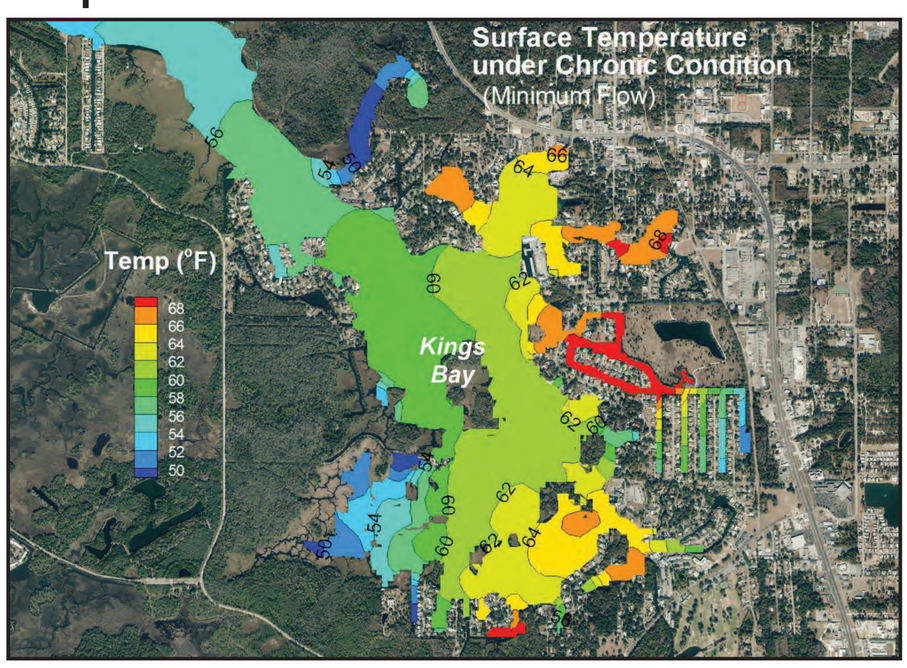




The 9-year simulation period: 10/06/2006 – 11/31/2015

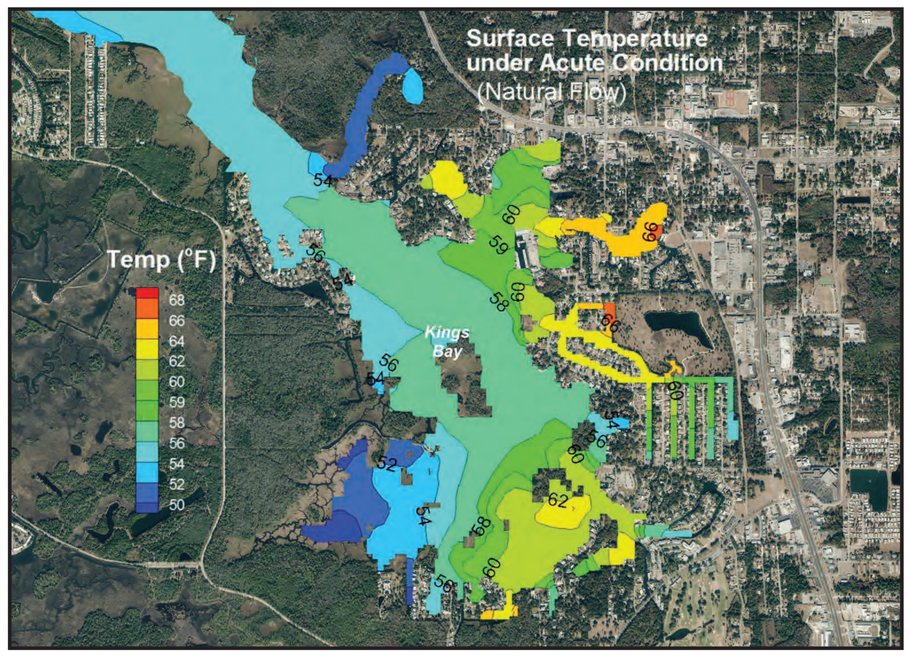
Comparison of surface temperature distributions during a 72-hour period for the natural and proposed minimum flows

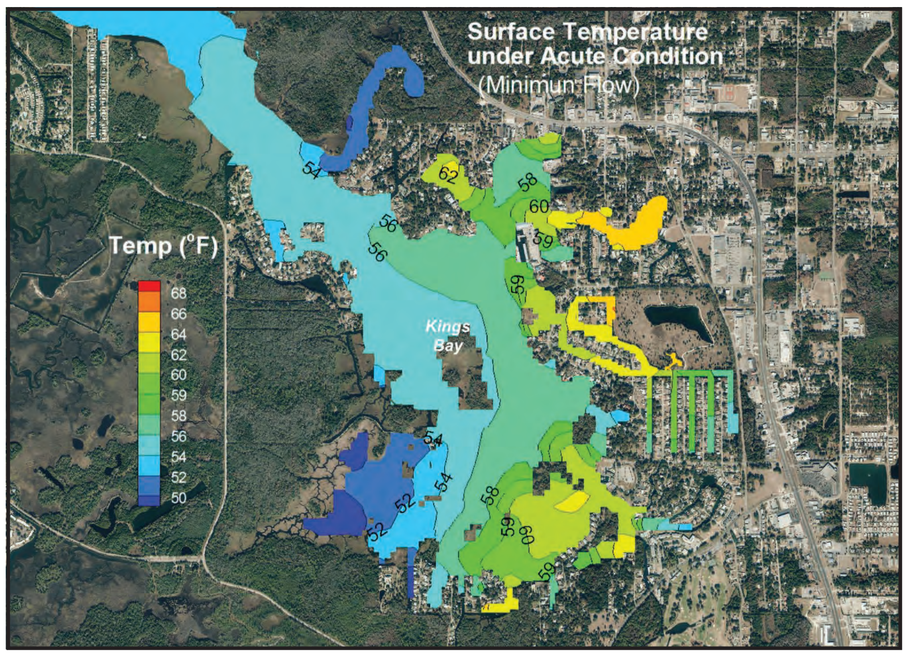




Manatees like water temperature warmer than 68 F (20 C). When water temperature drops below 68 F, some cannot survive more than 4–7 days. To be conservative, we studied thermal habitats during the coldest 3-day (or 72-hour) time frame in our MFL evaluation. The coldest 72 hours in the Crystal River/Kings Bay System (CRKB) was Jan. 10–13, 2010. This 72 hours is considered the chronic condition for manatees in the MFL evaluation.

Comparison of surface temperature distributions during a 4-hour period for the natural and proposed minimum flows



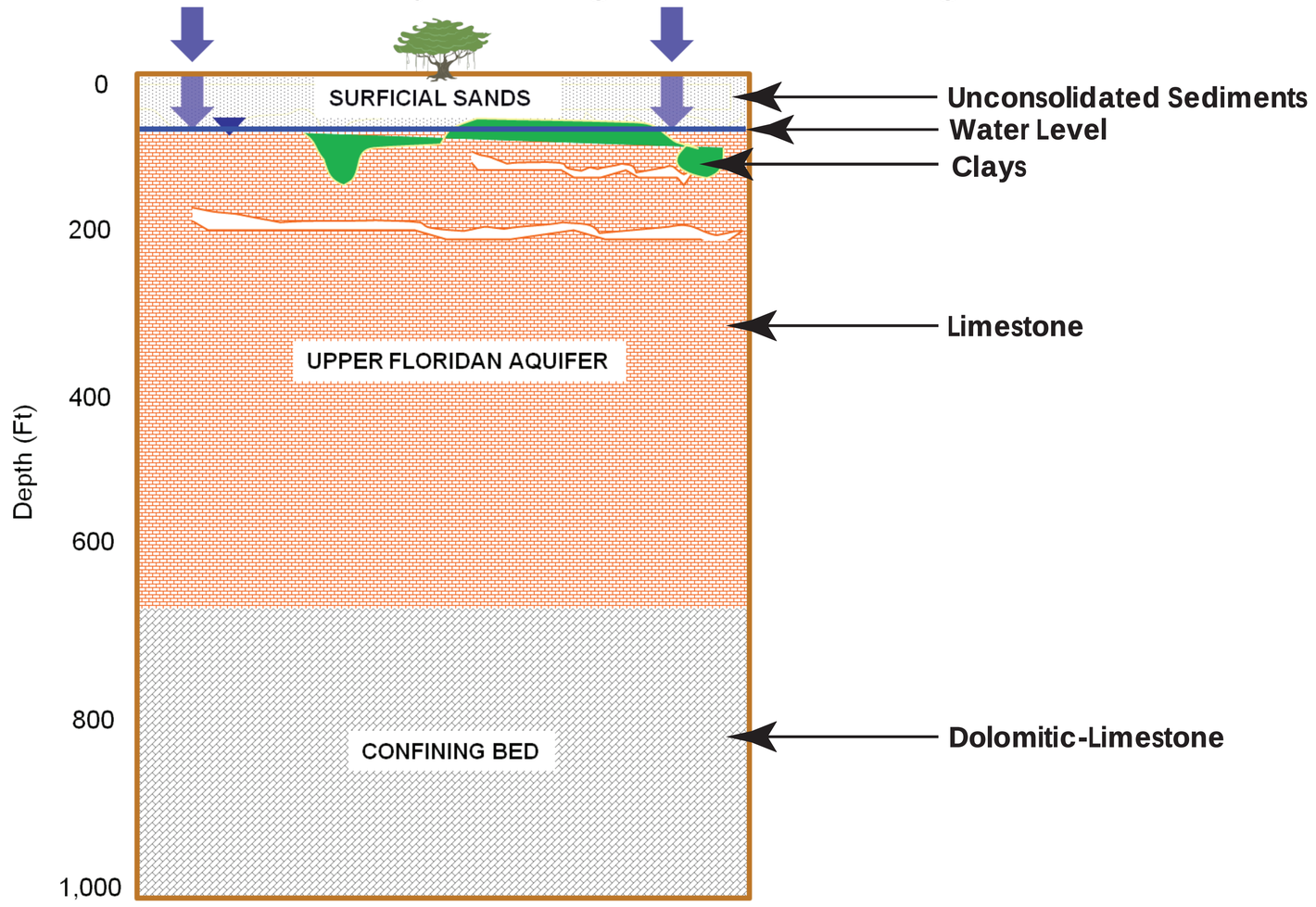


When water temperature drops below 59 F (15 C), some manatees have a hard time surviving for more than 4 hours. The coldest 4 hours in CRKB was 5:30–9:30 a.m. on Feb. 13, 2010. This 4 hours is considered the acute condition for manatees in the MFL evaluation.

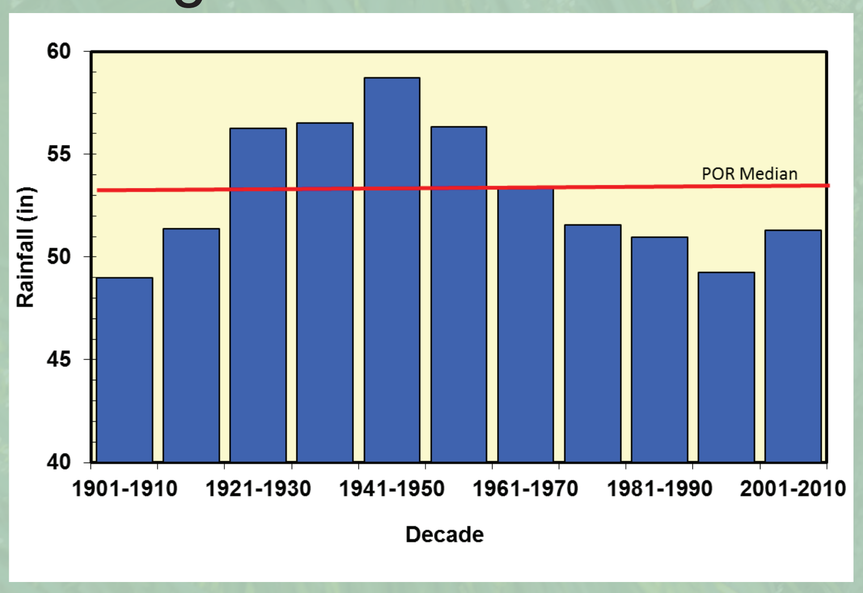
Crystal River/Kings Bay System

Geology

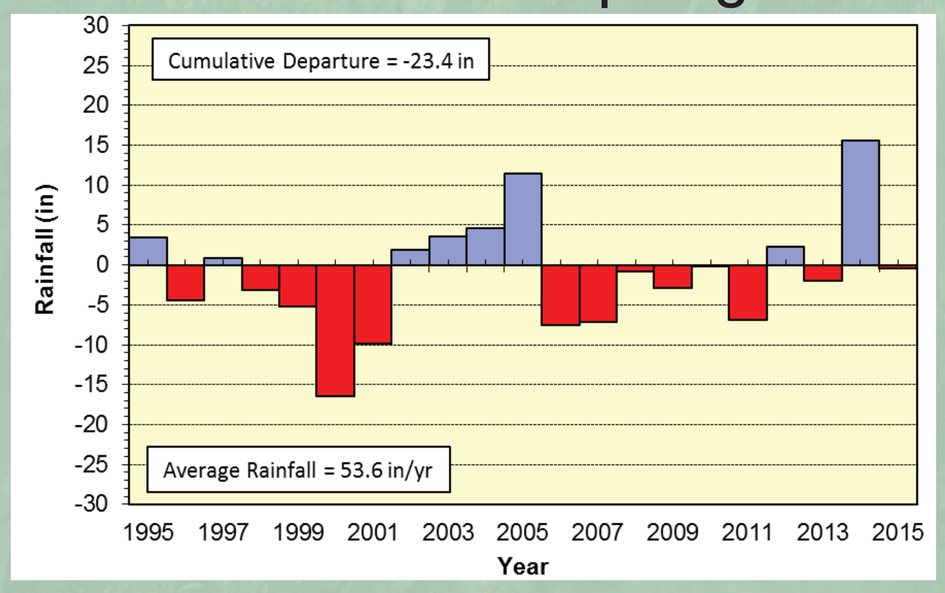
20 inches/yr. – Highest Recharge in the State



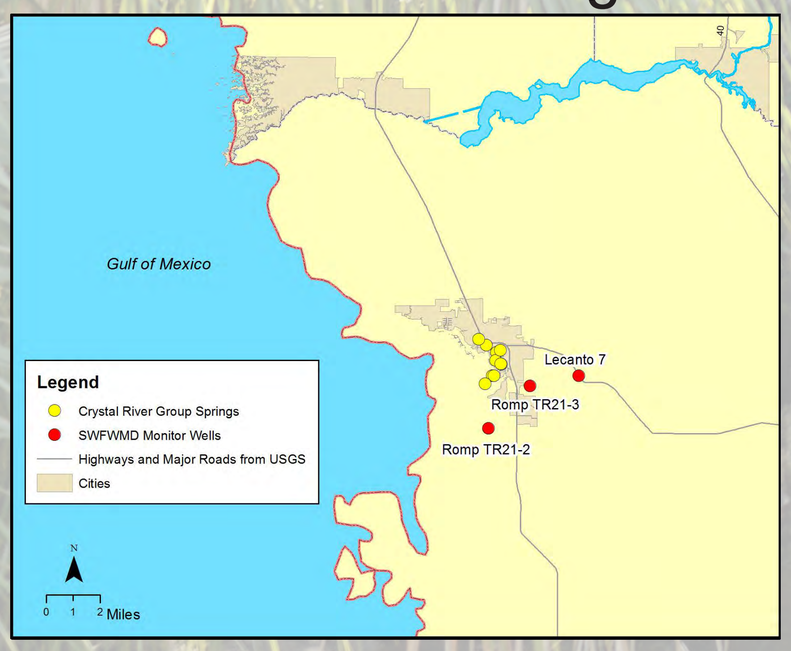
Long-term rainfall trends



Radar rainfall in springshed

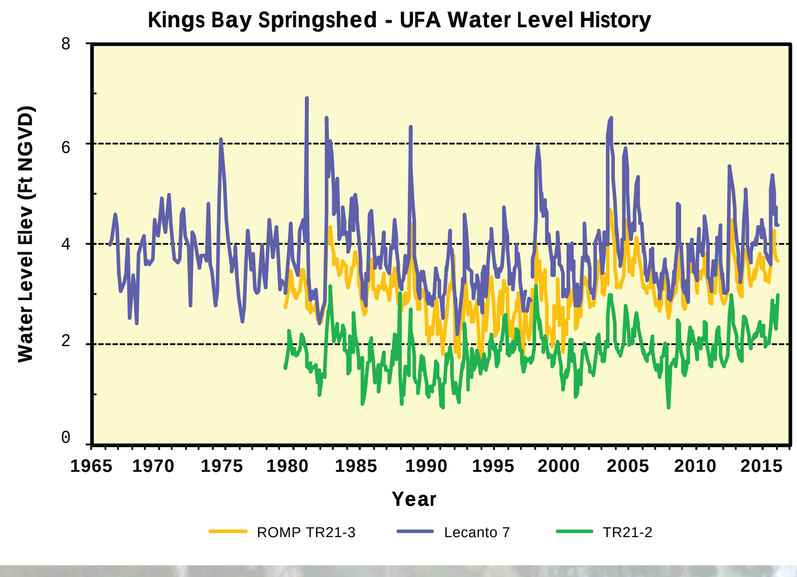


Groundwater Monitoring Stations



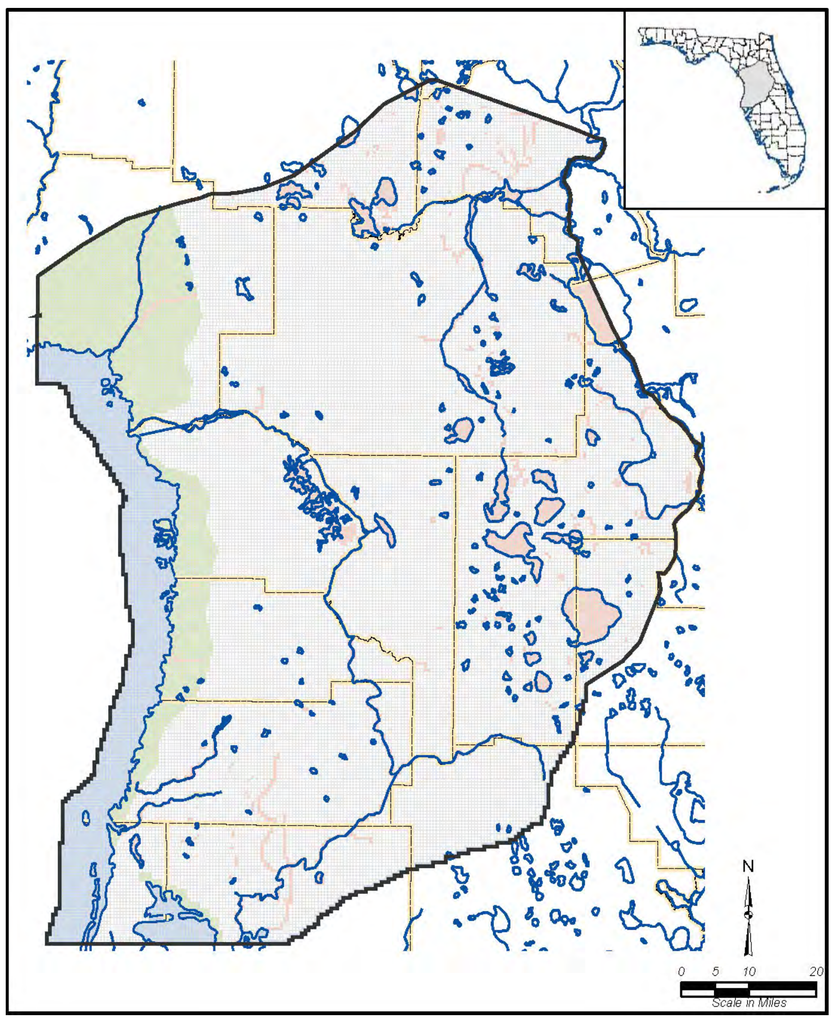
Groundwater Levels

Water levels are stable or slightly rising

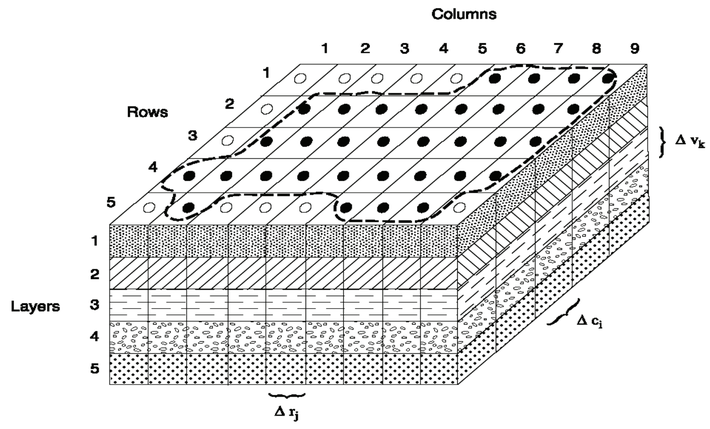


Crystal River/Kings Bay System

Northern District Model (Version 5.0)



- **Based on geologic data from 50 sites and matching 300 well water levels**
- **Peer Reviewed by Outside Experts:**
  "NDM, Version 5.0, is the best numerical groundwater flow model currently available for assessing the effects of withdrawals in the central (Florida) springs region."
- **Model developed cooperatively with St. Johns River Water Management District, Marion County and Withlacoochee Regional Water Supply Authority**

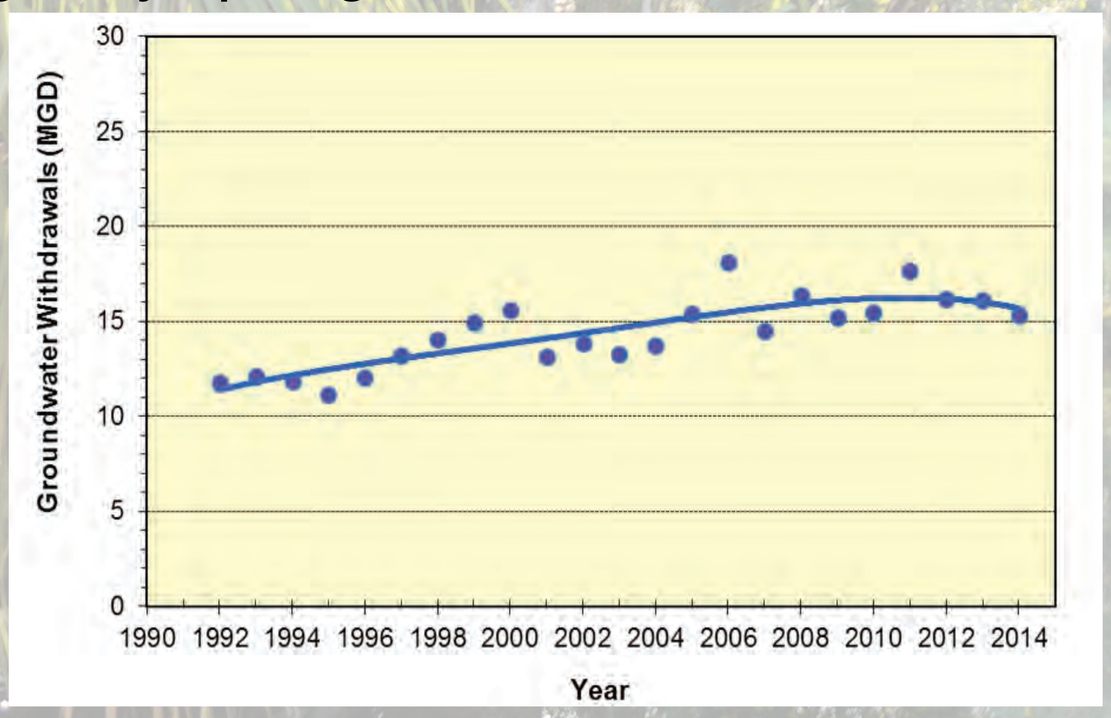


Springs Flow Change from Groundwater Withdrawals

Year	Flow Reduction (cubic feet/second)	Flow Reduction %
2010	6.9	-1.5
2014	5.2	-1.1
2035	10.8	-2.4
2035 w/Conservation and Reuse	9.6	-2.1

- **Geology and relatively low groundwater use have led to small flow changes of 1 to 2 percent.**
- **No recovery or additional prevention strategy is needed at this time based on current springflow decline of 1 to 2 percent due to withdrawals. This is projected to increase to 2.4 percent in 2035. The proposed MFL allowable reduction due to withdrawals is 11 percent.**

Kings Bay Springshed Groundwater Use History

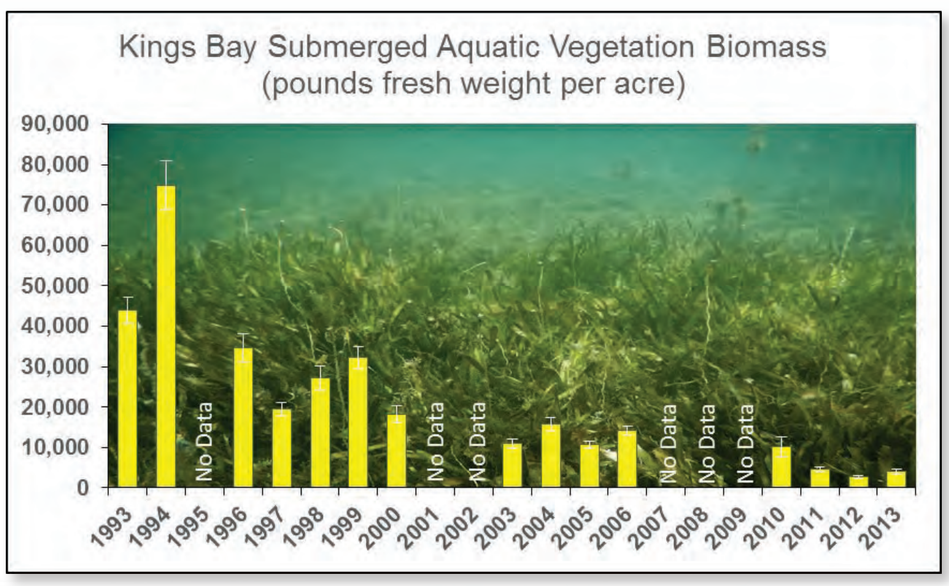


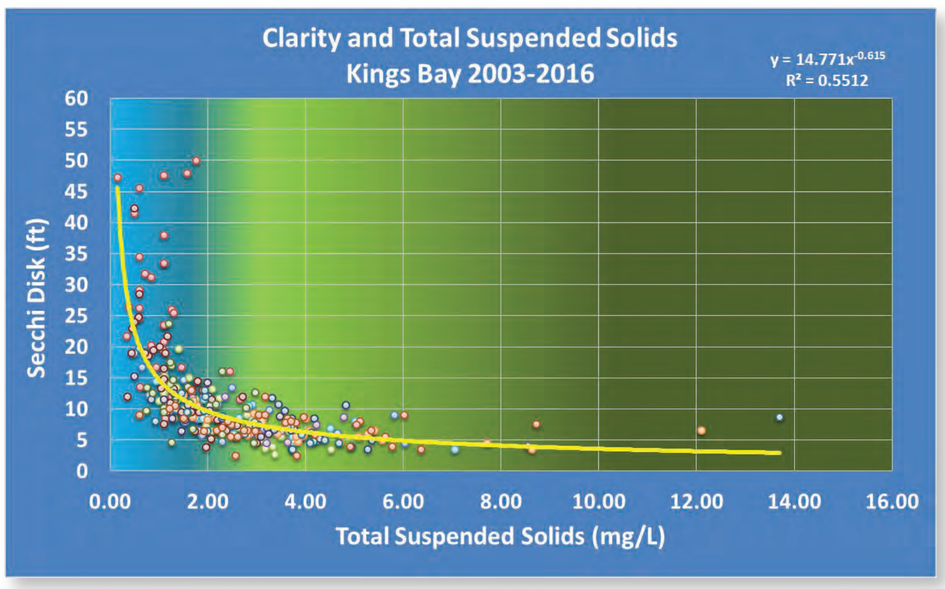
What is Driving Water Clarity in Kings Bay

Water Clarity is a function of:
- **Chlorophyll**
- **Suspended Solids (Turbidity)**

Chlorophyll is a function of:
- **Submerged Aquatic Vegetation**
- **Salinity**
- **Nutrients (primarily Phosphorous)**
- **Discharge and Residence Time**

Total Suspended Solids is a function of:
- **Submerged Aquatic Vegetation**





NOT ALL ALGAE ARE CREATED EQUAL

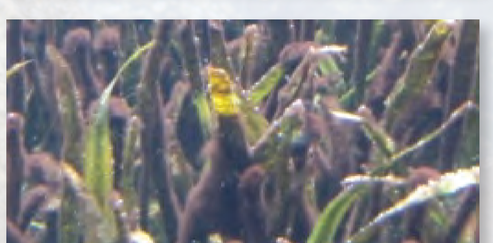
- **Not always bad – integral to a healthy ecosystem**
- **Produce chlorophyll and need sunlight and nutrients**
- **Microscopic (micro-algae) to large individuals (macro-algae)**

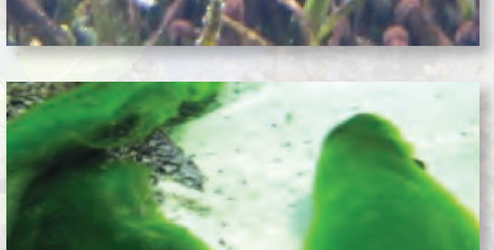
Phytoplankton
- **Live in the water column**
- **What turns water green**
- **Can block sunlight from reaching SAV**

Epiphytic Algae
- **Grow on the surface of SAV**
- **Can be beneficial in limited quantities**
- **Can smother SAV in large quantities**

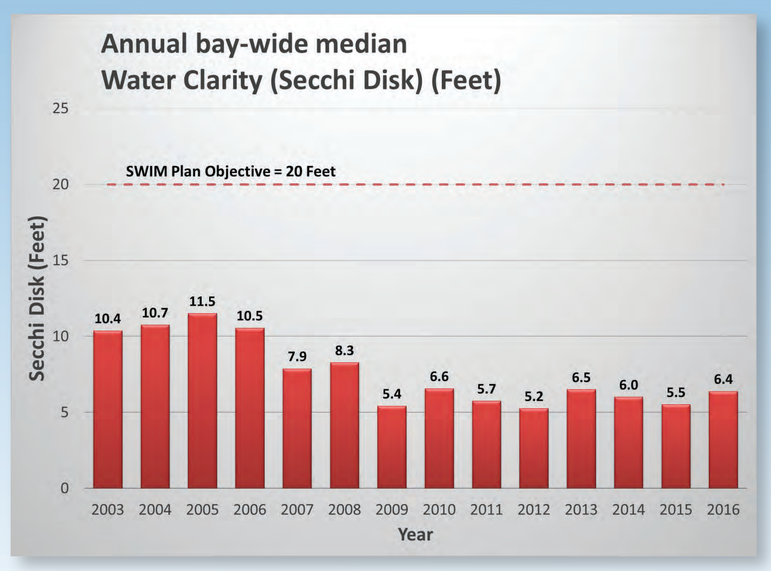
Benthic Algae
- **Filamentous (Lyngbya and Chaetomorpha)**
- **Can form mats or float on surface**
- **Can smother SAV in large quantities**

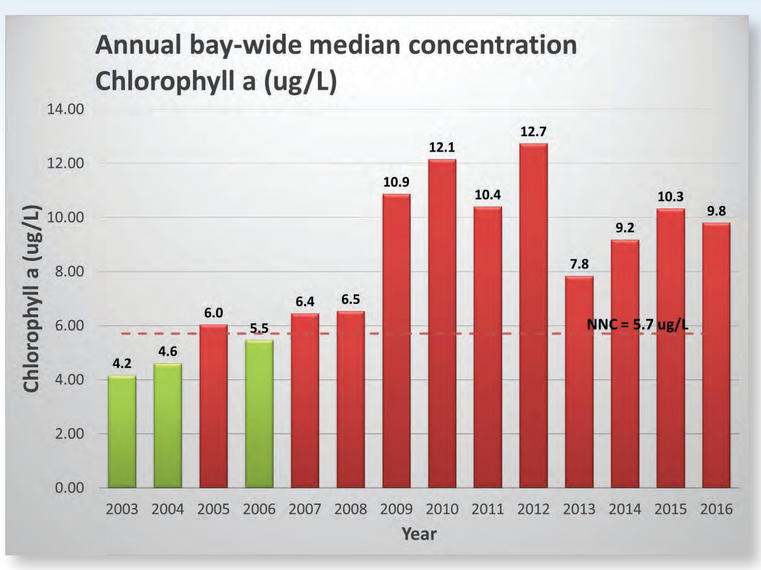


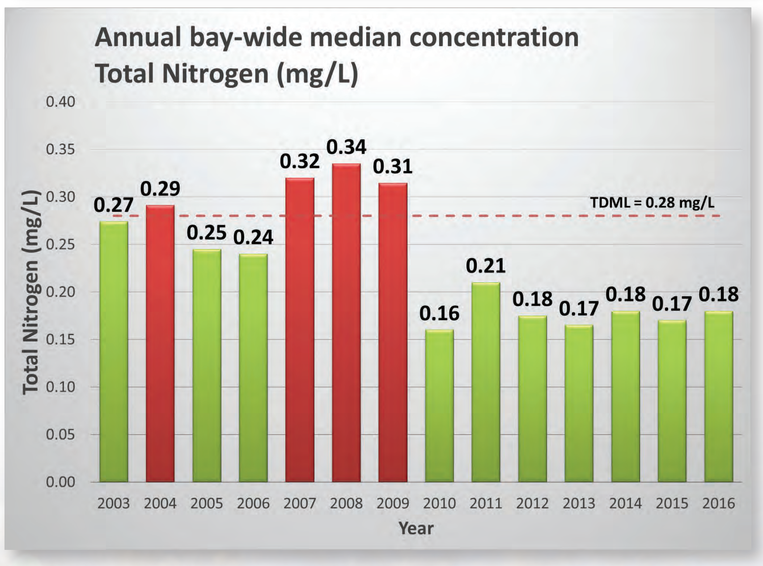


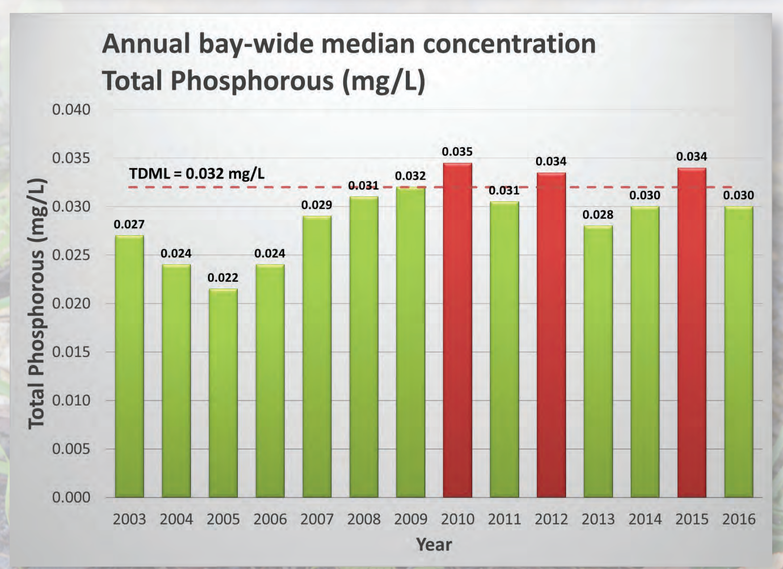


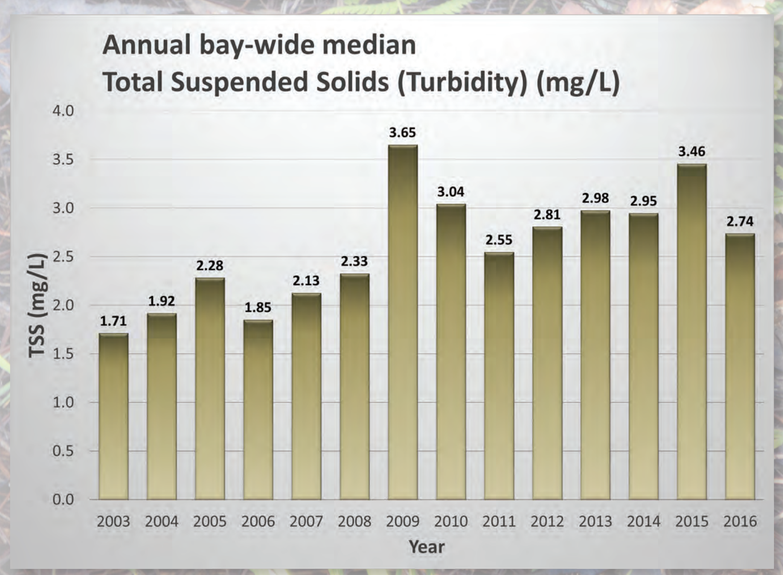
Water Quality in Kings Bay











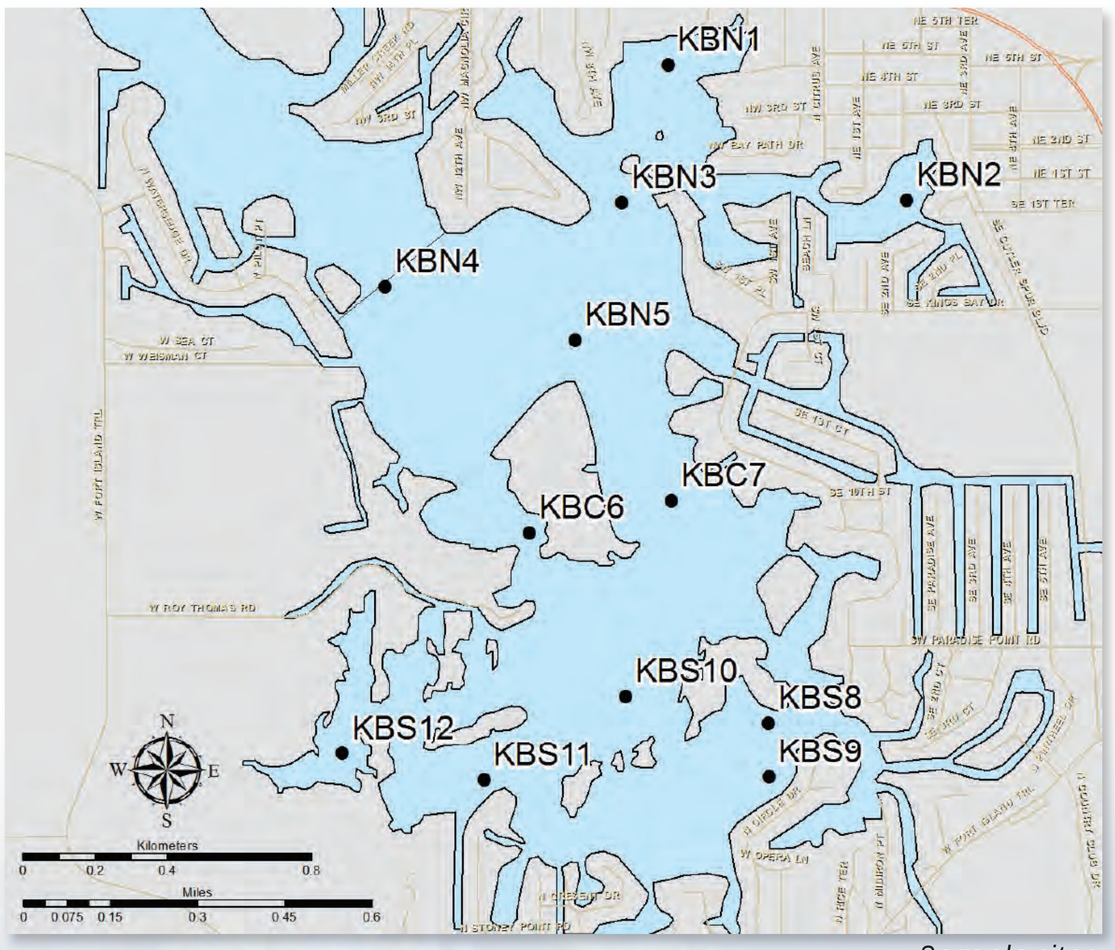
Water Chemistry in Kings Bay is very complex
Bay-wide over the period 2003-2016:

- **Water clarity has declined over time and remained relatively constant over the past 7 years (~6 ft.)**
- **Chlorophyll has increased over time and remained relatively constant over the past 7 years (~10 ug/L)**
- **Suspended Solids (Turbidity) has increased over time**
- **Nitrogen levels are low in the bay and have shifted to even lower levels since 2010, even though nitrate levels in most of the spring vents continues to increase**
- **Phosphorous levels are greater over the past 7 years than in the previous 7 years**

Drivers of Water Chemistry in Kings Bay include:

- **Sea-level Change (current rate of rise ~ one inch per decade)**
- **Submerged Aquatic Vegetation (SAV)**
- **Pulsed events (Storm Surge)**
- **Tides**
- **Winds**
- **Rainfall**
- **Discharge**

Linkages between Discharge and Water Chemistry continue to be investigated



Sample sites

Kings Bay Ambient Water Quality Network
2003-Present, 12 Stations, Currently Sampled Quarterly:

Lab Parameters

- **Ammonia**
- **Calcium**
- **Total Organic Carbon**
- **Chlorophyll a**
- **Pheaophytin**
- **Color**
- **Iron**
- **Total Suspended Solids**
- **Volatile Suspended Solids**
- **Magnesium**
- **Nitrate+Nitrite**
- **Total Notrogen**
- **Total Phosphorous**
- **Orthophosphorous**
- **Potassium**
- **Sodium**
- **Turbidity**

Field Parameters

- **Secchi Disk**
- **Specific Conductivity**
- **Salintiy**
- **pH**
- **Dissolved Oxygen**
- **Temperature**
- **Total Depth**



Collecting samples