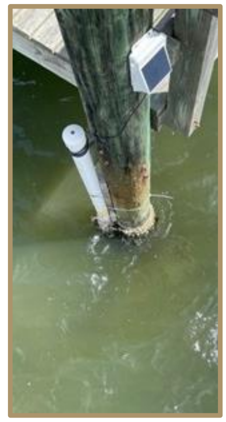
Restore Lagoon Inflow Research (Phase 2)
Project Summary



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We would like to thank the following regulatory agencies and organizations that we consulted on Phase 2 of the project:

- Applied Ecology, Inc.
- Brevard County Board of County Commissioners
- Brevard County Natural Resources Management Department
- Canaveral Port Authority
- Florida Department of Environmental Protection
- Florida Fish and Wildlife Conservation Commission Melbourne Fisheries Lab
- Harbor Branch Oceanographic Institute
- Herndon Solutions Group
- Indian River County Board of County Commissioners
- Indian River Lagoon National Estuary Program and IRL Council
- Marine Resources Council
- National Aeronautics and Space Administration (NASA) Kennedy Space Center
- St. Johns River Water Management District
- University of Central Florida Genomics and Bioinformatics Cluster
- U.S. Army Corps of Engineers

The photographs on the cover were provided by the Florida Tech Principal Investigators on this project.

Executive Summary

Over 50 years of impacts from a growing human population have taken a tragic toll on the Indian River Lagoon (IRL) system. Excessive nutrients and all forms of pollution from human activity flow overland and through groundwater to the lagoon. The seagrasses, clams, and oysters are nearly gone, displaced by nutrient laden muck, polluted water, and algal blooms. With the loss of the majority of seagrasses, manatees are dying in record numbers as they are unable to find food. Fish populations that survived the 2011 superbloom now struggle to adjust to rapidly changing conditions. Algae that once unnoticeably cycled through the seasons in clear water now cloud the water, as blooms of one dominant species quickly die out only to be replaced by the next dominant species in an unbalanced, sometimes hypoxic or anoxic, high nutrient (eutrophic) system.

Water circulation in the lagoon is restricted on all sides, increasing risk of eutrophication and ecosystem collapse. Previous federal development activity supporting space and defense projects cut off the finger flows of Banana Creek, eliminating the northern connection of the Banana River Lagoon (BRL) to IRL. To the east, natural episodic connections between the coastal ocean and IRL system have been lost with the hardened development of the barrier islands, while the benefits of water circulation through the five maintained inlets are limited by the many causeways that restrict flow north and south. To the west, polluted water which once largely drained to the St. Johns River now flows to the IRL system.

Deliberate and timely restoration of lagoon hydrology can improve water quality and help restore the rapidly deteriorating lagoon ecosystem. Elected officials; local, state, and federal government agencies; and stakeholders in the IRL region are exploring a variety of approaches to help restore the lagoon. The Restore Lagoon Inflow Research project will help determine the viability of a permanent ocean inflow system as a potential additional tool to stabilize and restore the lagoon.

With funding from the Florida Legislature in fiscal year 2020, the Florida Institute of Technology (Florida Tech) completed Phase 1 of a multi-phase research project to explore water quality improvement within the IRL system by enhancing ocean inflows. This first phase gathered baseline data and conducted modeling and experiments on water quality, biological parameters, and hydrologic conditions at candidate locations for a temporary ocean inflow system. The Florida Legislature authorized funding for Phase 2 in fiscal year 2021, which built upon the lessons learned from Phase 1, and focused on planning for construction and implementation of a small-scale, temporary ocean inflow system and the studies required to evaluate its effectiveness. The efforts in Phase 2 included site selection, agency and stakeholder engagement, conceptual engineering and optimization, pre-permitting briefings, expanded ecosystem modeling, and baseline data collection. The Phase 1 and Phase 2 results, when combined with findings from the temporary inflow pilot system, will allow for an informed determination of the feasibility and impacts of a potential permanent ocean inflow system.

A multi-disciplined team of research professionals, supported by community partners, Florida Tech staff, students, and engineering professionals from Tetra Tech, Inc., was assembled to provide expertise in:

- Modeling and Engineering – Dr. Gary Zarillo, Dr. Robert Weaver, and Tetra Tech
- Geochemistry – Dr. Austin Fox
- Biology – Dr. Kevin Johnson, Dr. Ralph Turingan, Dr. Jeff Eble, and Dr. Jesse Blanchard

Project Overview

The multi-phased Restore Lagoon Inflow Research project is envisioned to include the baseline monitoring, design, permitting, implementation, and modeling of a system providing temporary ocean inflow to IRL to help determine the viability of a permanent ocean inflow system. By improving understanding and management of the IRL system, the study results will also help to address several actions in the IRL National Estuary Program Comprehensive Conservation and Management Plan, including specifically addressing action Connected Waters-5 which calls for a pilot project to assess the benefits and risks of enhanced ocean exchange with the lagoon.

Figure ES-1. Map of the proposed inflow pilot system site and pipeline

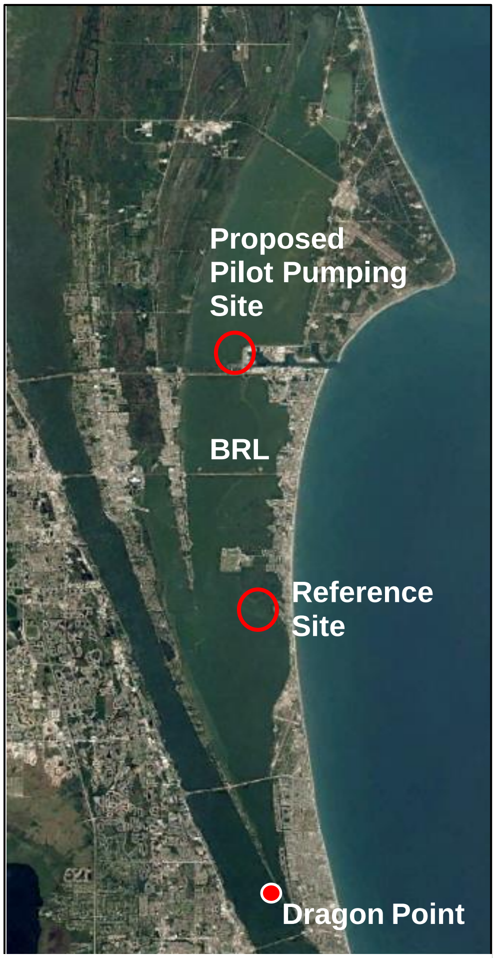

Figure ES-2. Map showing BRL proposed pilot and reference site

For future phases to complete the project, the pilot system design developed in Phase 2 will be revised to include changes discussed in the pre-application meetings with the agencies and feedback from local stakeholders, and will be used to obtain the necessary permits. The project bid documents will then be created, the request for proposals drafted and sent out for bidding, and an award made for construction of the temporary inflow pilot system. The temporary inflow pump system will be constructed in accordance with the U.S. Army Corps of Engineers and Environmental Resource Permit requirements.

The temporary inflow pump system is proposed to be operated for one year in parallel with continued focused research, monitoring, and modeling. This approach allows for data to be collected on changes due to small-scale ocean inflow at the study site compared to a reference site outside the influence of pumping, to directly assess impacts on focal biological communities and to validate dissolved oxygen (DO), nutrient, and chlorophyl-a (Chl-a) model predictions. The temporary pump system established for the project will be decommissioned at the end of the research period, with the piping and pump removed from the site. The results of the full Restore Lagoon Inflow Research project will be summarized to provide information and analysis to stakeholders and decision-makers on the viability of a permanent ocean inflow system.

Proposed Inflow Site

Based on data collected during Phase 1 and discussions with agencies and stakeholders, Phase 2 identified the northern BRL as the most feasible and cost-effective location of a temporary inflow research site. BRL is a sub-basin of IRL that lies between Cape Canaveral and Merritt Island and extends from the National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC) to Dragon Point. It is poorly flushed with no direct connection to the ocean, which results in long water residence times and increased vulnerability to nutrient accumulation.

The proposed temporary inflow system would extract water from the ocean side of the Canaveral Lock system and discharge to BRL via the cove to the west of Avocet Lagoon (**Figure ES-1**). A pump station is proposed that pumps a relatively small volume of 0.5 cubic meters per second of seawater through a pipe system above ground to the lagoon. The cove configuration will restrict flow movement from the outfall location and provide a concentration gradient to evaluate changes on water quality, geochemistry, and biology. A reference site in the central BRL was proposed (**Figure ES-2**), which was identified through model evaluation and field sampling as comparable to the proposed inflow site and outside the influence of the pilot system. The proposed pilot system configuration was selected to preserve the reference site while minimizing cost and impacts to existing infrastructure, public access, and natural resources.

Data Collection and Modeling

Florida Tech adapted the project approach based on data collected while addressing concerns/questions from stakeholders. Internal project meetings and stakeholder meetings were focused on providing the lowest cost and least invasive approach to implement the temporary inflow pilot system, without sacrificing the validity and quality of the pilot research project.

An IRL Environmental Fluid Dynamics Code model was updated to provide numerical predictions of hydrodynamics, flushing rate, water quality, and phytoplankton concentration with and without enhanced inflow. Model boundary conditions used data from St. Johns River Water Management District and Harbor Branch Oceanographic Institute IRL Observation Network, with watershed inputs from the Spatial Watershed Iterative Loading model developed by Applied Ecology and internal nutrient loading and groundwater inflow predictions compiled by Florida Tech.

Figure ES-3. Collecting water samples from a benthic chamber

Acoustic Doppler Current Profiler units were deployed in BRL near the Barge Canal, Dragon Point, and Sykes Creek to improve modeling of current directions and velocities. Data on temperature, salinity, and nutrients were also collected with a focus on the proposed temporary inflow pilot system site, reference site, and Port Canaveral. Uptake and release (fluxes) of nutrients from sediments and water column were evaluated in the field and using laboratory bench tests of IRL sediments in simulated inflow conditions (**Figure ES-3**) with the goal of investigating inflow potential to promote natural nutrient removal through improved bottom water circulation, lower water temperature, and higher and more stable DO concentrations.

In addition, biological data collection efforts for seagrass, drift algae, phytoplankton and harmful algae, benthic infauna, fish community, and environmental deoxyribonucleic acid (eDNA) continued from Phase 1. These data improve understanding of the BRL ecosystem, providing biological baselines for comparison to conditions with the proposed temporary inflow pilot system in place to identify effects of enhanced inflow to key species, communities, and habitats.

Highlighted Key Findings

Stabilizing DO and reducing water temperature can improve natural nutrient removal.
Under low oxygen conditions (hypoxia), sediments were found to be a source of dissolved nutrients to overlying water. Inflow is predicted to stabilize DO concentrations and mitigate occurrences of hypoxia, which would improve binding of orthophosphate by sediments, reduce total nitrogen (TN), and promote nutrient ratios that are less favorable for harmful algal bloom (HAB) species. Predicted lower temperatures resulting from just the temporary small-scale inflow system are estimated to prevent 1.6 metric tons of TN and 0.7 metric tons of total phosphorus (TP) from entering the lagoon, with an estimated value of $9 million per year based on the current average costs for lagoon TN and TP removal.

Net nutrient reduction is predicted as a result of enhanced inflow.
Models and field data suggest that measurable impacts of inflow will be limited to the northern compartments of the IRL system. This is supported in water quality projections for Sebastian Inlet, which indicate increased water discharge but no detectable change in nutrient concentrations. Higher inlet water exchange rates with inflow are predicted to increase nutrient loads to the coastal ocean at Sebastian Inlet by less than 1%. However, when factoring in the predicted nutrient reduction from the increased DO concentrations and lower water temperatures, a net reduction of nutrient loading is anticipated with enhanced inflow.

Water quality determines fish distribution and local population size.
Significant responses were shown to increased inflow by ecologically and recreationally valuable fishes. Many fishes are highly mobile and will adjust habitat use in response to water quality conditions. Model projections suggest the local populations of five of eight species of interest would increase and three species would decrease with enhanced inflow. Significant positive and negative associations between local fish population size and Chl-a concentrations were detected and include a strong decline in nearly all species of interest following the 2011 "superbloom." Complimentary assessment of fish eDNA detection patterns support tracking of biodiversity loss or recovery over time against an established fixed baseline. eDNA detection patterns highlighted the negative impacts of frequent HAB outbreaks on BRL fish diversity, and presence of species rich and taxonomically diverse fish communities at sites buffered against eutrophication impacts.

Biological baseline allows tracking system response to inflow.
Phase 2 monitoring of planktonic communities identified 62 diatom, 16 dinoflagellate, and dozens of other algal species present in the pilot project area. In a healthy system, these species cycle nutrients without excessive algal blooms. In the current high nutrient IRL system, populations of one species dominate for a period, die off, sink to the bottom, increase biological oxygen demand in the sediments, and promote future HAB outbreaks. Concurrent benthic community monitoring identified 105 infauna species (species living in the sediments) at the study sites, showing that there is an opportunity for restoration of natural nutrient removal.

Low pumping volumes provide a cost-effective and low impact research design.
A natural cove a short distance from ocean water was selected to confine inflows and allow development of measurable concentration gradients in water quality parameters at relatively low pumping volumes. This design significantly reduces project installation and operation costs and potential negative impacts, while also preserving a similar reference site outside the influence of pilot pumping to test predicted impacts of inflow on lagoon water quality, nutrient removal, and biology using scientifically sound methods.