Save Our Indian River Lagoon Project Plan 2018 Update
for
Brevard County, Florida




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List of Acronyms and Abbreviations

AFB	Air Force Base
BAM	Biosorption Activated Media
BMAP	Basin Management Action Plan
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBPO	Chesapeake Bay Program Office
CCMP	Comprehensive Conservation and Management Plan
DMMA	Dredged Material Management Area
E. coli	Escherichia coli
EMV	Expected Monetary Value
ERU	Equivalent Residential Unit
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FWC	Florida Fish and Wildlife Commission
FY	Fiscal Year
GI	Green Infrastructure
GIS	Geographic Information System
I&I	Inflow and Infiltration
IFAS	Institute of Food and Agricultural Sciences
IRL	Indian River Lagoon
LID	Low Impact Development
MAPS	Managed Aquatic Plant Systems
MGD	Million Gallons Per Day
NEP	National Estuary Program
ppb	Parts per Billion
SJRWMD	St. Johns River Water Management District
SRF	State Revolving Fund
STEP	Septic Tank Effluent Pumping (system)
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWIL	Spatial Watershed Iterative Loading (model)
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UF	University of Florida
USEPA	U.S. Environmental Protection Agency
WRF	Water Reclamation Facility
WWTF	Wastewater Treatment Facility

Executive Summary

The Indian River Lagoon (IRL) system includes Mosquito Lagoon, Banana River Lagoon, and Indian River. This is a unique and diverse system that connects Volusia, Brevard, Indian River, St. Lucie, and Martin counties. The IRL is part of the National Estuary Program (NEP), one of 28 estuaries of National Significance, and has one of the greatest diversity of plants and animals in the nation. A large portion of the IRL system, 71% of its area and nearly half its length, is within Brevard County and provides County residents and visitors many opportunities and economic benefits.

However, the balance of this delicate ecosystem has been disturbed as development in the area has led to harmful impacts. Stormwater runoff from urban and agricultural areas, wastewater treatment facility (WWTF) discharges, septic systems, and excess fertilizer applications have led to harmful levels of nutrients and sediments entering the lagoon. These pollutants create cloudy conditions in the lagoon and feed algal blooms, both of which negatively affect the seagrass community that provides habitat for much of the lagoon's marine life. In addition, these pollutants lead to muck accumulation, which releases (fluxes) nutrients and hydrogen sulfide, depletes oxygen, and creates a lagoon bottom that is not hospitable to seagrass, shellfish, or other marine life.

Efforts have been ongoing for decades to address these sources of pollution. Despite significant load reductions, in the last five years, signs of human impact to the IRL system have been magnified. In 2011, the "superbloom" occurred, an intense algal bloom in the Mosquito Lagoon, Banana River Lagoon, and North IRL, as well as a secondary, less intense bloom in the Central IRL. There have also been recurring brown tides; unusual mortalities of dolphins, manatees, and shorebirds; and large fish kills due to low dissolved oxygen from decomposing algae.

Local governments and the St. Johns River Water Management District (SJRWMD) have been proactive in implementing projects over the last several decades. However, to restore the lagoon to health and prosperity, additional funds are needed to eliminate current excess loading and remove the legacy of previous excess loading. Therefore, the County placed a Save Our Indian River Lagoon ½ cent sales tax referendum on the ballot in November 2016, which passed and will provide a funding stream for the types of projects listed in this plan for Brevard County and its municipalities.

The Save Our Indian River Lagoon Project Plan outlines local projects planned to meet water quality targets and improve the health, productivity, aesthetic appeal, and economic value of the lagoon. Implementation of these projects is contingent upon funding raised through the ½ cent sales tax. This sales tax funding would also allow the County to leverage additional dollars in match funding from state and federal grant programs because the IRL ecosystem is valued not only in Florida but also nationally. Funding implementation of this plan would help to restore this national treasure. If additional funding is provided through matching funds from other sources, additional projects may be implemented, which would increase the overall plan cost, and/or project timelines may be moved up to allow the benefits of those projects to occur earlier than planned. Lagoon ecosystem response may lag several years behind completion of nutrient reductions; however, major steps must begin now to advance progress on the long road to recovery.

In the development of this plan, Subject Matter Experts were consulted to provide feedback on the plan elements. The experts all agreed that there is a "critical mass" of nutrient reductions that must be achieved to see a beneficial result in the IRL. This critical level of nutrient reduction will be achieved through the implementation of the projects in this plan. During plan development, it was estimated that the benefit of restoring the lagoon has a present value of $6 billion and a cost of $300 million. Therefore, implementing this plan to restore the IRL is an excellent investment in the future of Brevard County's community and economy with a benefit to cost ratio of 20:1.

In order to restore the lagoon's balance, Brevard County seeks to accelerate implementation of a multi-pronged approach to **Reduce** pollutant and nutrient inputs to the lagoon from fertilizer, reclaimed water from WWTFs, septic systems, and stormwater; **Remove** the accumulation of muck from the lagoon bottom; **Restore** water-filtering oysters and related lagoon ecosystem services; and monitor progress to **Respond** to changing conditions, technologies, and new information by amending the plan to include actions that will be most successful and cost-effective for significantly improving the health, productivity, and natural resilience of the IRL.

The portfolio of projects in this plan were selected as the most cost-effective suite of options to achieve water quality and biological targets for the lagoon system. Investment has been distributed among a set of project types with complimentary benefits to reduce future risk of failure. Nearly two-thirds (2/3) of the effort and expense is directed toward muck removal to address decades of past excess nutrient loading. Approximately one-third (1/3) of the effort is split among multiple efforts to reduce incoming load to healthy levels, restore natural filtration, measure success, and respond with annual plan updates. The plan projects have been prioritized and ordered to deliver improvements to the lagoon in the most beneficial spatial and temporal sequence. The implementation of this plan is expected to result in a healthy IRL system.

This 2018 Update to the Save Our Indian River Lagoon Project Plan contains the second set of project updates, new approved projects, and schedule accelerations to the plan. Local stakeholders submitted projects to Brevard County for inclusion in the plan. The appointed Citizen Oversight Committee reviewed the submitted projects and made a recommendation to the Board of County Commissioners on which projects should be added to the SOIRLPP. This update includes those projects that were reviewed by the Citizen Oversight Committee and approved for inclusion by the Board of County Commissioners.

A summary of the types of projects included in the plan, as well as the associated costs and nutrient reduction benefits are shown in **Table ES-1**. The timing of the projects is shown in **Figure ES-1**. Despite the considerable cost of restoration, analysis demonstrates that the economic cost of inaction is double the cost of action. Furthermore, although there are many tangible and intangible benefits for saving the lagoon, the readily estimated return on investment for three benefits – tourism, waterfront property values, and commercial fisheries – is 10% to 26% depending on how quickly the actions in this plan can be completed.

Table ES-1: Summary of Project Types, Costs, and Nutrient Reductions in the 2018 Update of the Save Our Indian River Lagoon Project Plan

Project Category	Project Type	Estimated Total Project Cost	Nitrogen Reductions (lbs/yr)	Average Cost/lb/yr of TN	Phosphorus Reductions (lbs/yr)	Average Cost/lb/yr of TP
Reduce	Public Education	$1,725,000	35,253	$49	2,413	$715
	WWTF Upgrades for Reclaimed Water	$15,319,837	51,114	$300	9,671	$1,584
	Sewer Lateral Rehabilitation	$840,000	$988	$850	$188	$4,468
	Septic System Removal by Sewer Extension	$38,009,069	46,744	$813	N/A	N/A
	Septic System Removal by Sewer Connection	$7,764,000	$17,530	$443	N/A	N/A
	Septic System Upgrades	$22,293,854	27,786	$802	-	-
	Stormwater Projects	$13,530,863	142,983	$95	20,408	$663
Remove	Muck Removal	$209,288,690	481,491	$435	72,324	$2,894
	Treatment of Muck Interstitial Water	$32,541,107	186,466	$175	244	TBD
Restore	Oyster Reefs	$9,985,260	24,991	$400	1,178	$8,476
	Vegetative Living Shorelines	$1,382,459	7,234	$191	2,483	$557
Respond	Projects Monitoring	$10,000,000	-	-	-	-
	Contingency	$17,905,769	-	-	-	-
Total	***Total***	***$380,585,908***	***1,022,580***	***$372 (average)***	***108,909***	***$3,495 (average)***

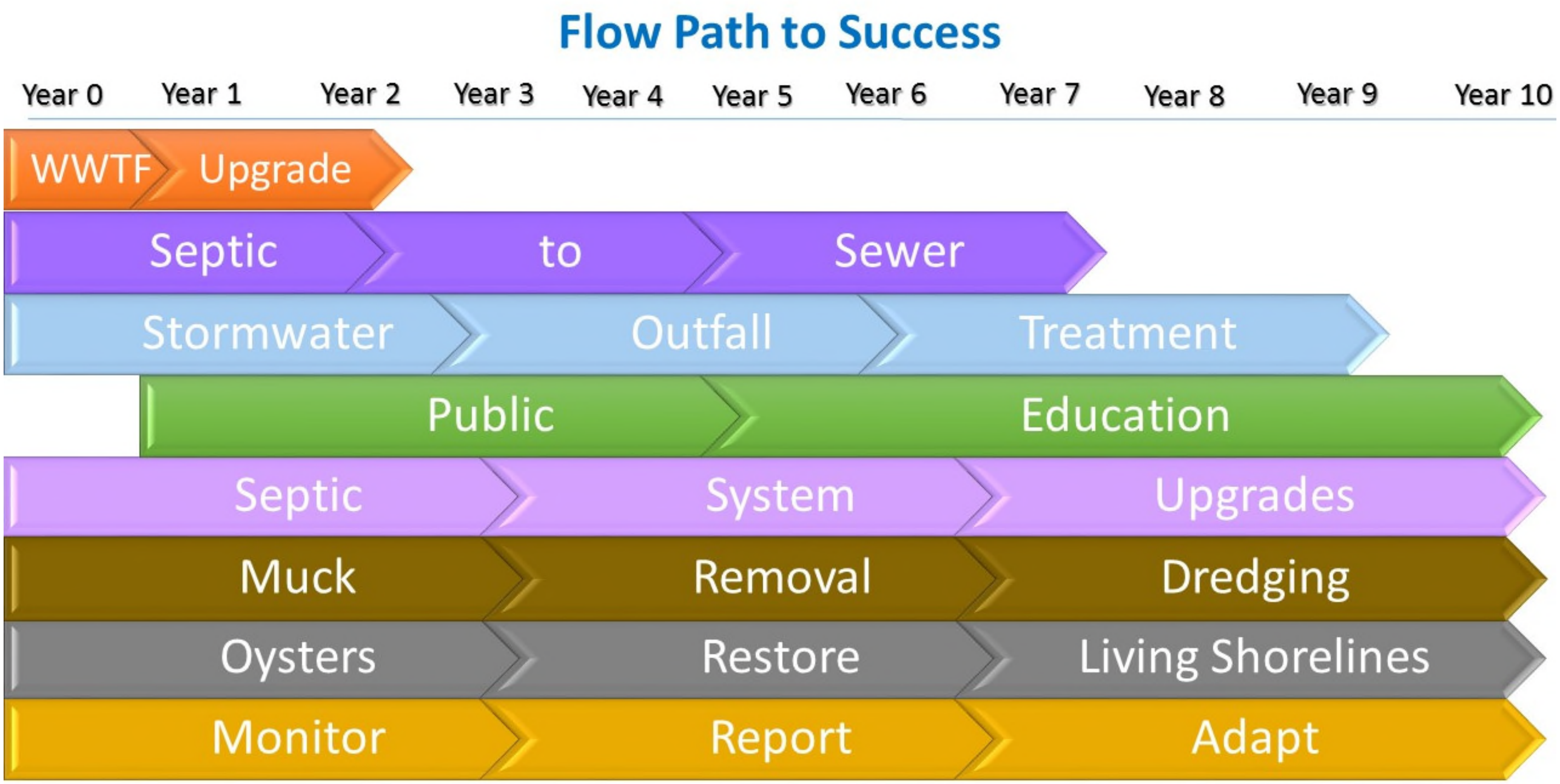


Figure ES-1: Save Our Indian River Lagoon Project Implementation Schedule

Section 1. Background

The Indian River Lagoon (IRL) system includes Mosquito Lagoon, Banana River Lagoon, and Indian River. A large portion of the IRL system, 71% of its area and nearly half its length, is within Brevard County (County) and provides County residents and visitors many opportunities.

However, the balance of this delicate ecosystem has been disturbed as development in the area has led to harmful impacts. Stormwater runoff from urban and agricultural areas, wastewater treatment facility (WWTF) discharges, septic systems, and excess fertilizer applications have led to harmful levels of nutrients and sediments entering the lagoon. In addition, these pollutants lead to muck accumulation on the lagoon bottom, which fluxes nutrients and creates a lagoon bottom that is not conducive to seagrass, shellfish, or benthic invertebrate growth.

Efforts have been ongoing to address these sources of pollution. The Indian River Lagoon System and Basin Act of 1990 (Chapter 90-262, Laws of Florida) was enacted to protect the IRL system from WWTF discharges and the improper use of septic tanks. The act includes three objectives: elimination of surface water discharges, investigation of feasibility of reuse, and centralization of wastewater collection and treatment facilities (Florida Department of Environmental Protection [FDEP] 2016). This act led to the removal of effluent discharges to the lagoon from more than 40 WWTFs (St. Johns River Water Management District [SJRWMD] 2016a).

Stormwater regulations were adopted in unincorporated Brevard County in 1978 and adopted statewide in 1989. Due to stormwater regulations, stormwater treatment systems were constructed along with all new development exceeding size thresholds. Privately owned and operated stormwater treatment systems have prevented more than a million pounds of sediments from entering the lagoon since 1989 (SJRWMD 2016a). Stormwater treatment projects also reduce nutrient inputs to the lagoon. In addition, dredging projects have been ongoing since 1998 to remove muck from the lagoon and major tributaries, including Crane Creek, Turkey Creek, and St. Sebastian River (SJRWMD 2016a). These stormwater treatment and muck removal projects contributed to significant improvements in water quality and water clarity in the lagoon, which allowed for a great expansion of seagrass from 2000-2010.

However, in the last five years, human impacts on the IRL system have been magnified. In 2011, the “superbloom” occurred, an intense algal bloom in the Mosquito Lagoon, Banana River Lagoon, and North IRL, as well as a secondary, less intense bloom in Central IRL. The extent and longevity of the bloom had a detrimental impact on seagrass. There have also been recurring brown tides; unusual mortalities of dolphins, manatees, and shorebirds; and large fish kills due to low dissolved oxygen from decomposing algae.

In 2009, to improve lagoon water quality and restore seagrass, FDEP adopted total maximum daily loads (TMDLs) for total nitrogen (TN) and total phosphorus (TP) allowed to discharge to the Banana River Lagoon, North IRL, and Central IRL. The purpose of these TMDLs is to reduce nutrients that lead to algae growth, which block sunlight from seagrass and create low dissolved oxygen conditions that affect fish in the lagoon. To implement these TMDLs, FDEP adopted three basin management action plans (BMAPs) that outline responsibilities for reductions by the local stakeholders, list projects, and stipulate a timeline for implementation. The intent of the nutrient reductions is to provide water quality conditions that should result in seagrass growth in the lagoon at historical levels. Brevard County has a major responsibility in all three BMAPs along with its 16 municipalities, Florida Department of Transportation (FDOT) District 5, Patrick Air Force Base (AFB), NASA – Kennedy Space Center, and agriculture.

Since 2012, Brevard County has led an effort with its municipalities, FDOT District 5, and Patrick AFB to update the estimates of nutrient loadings to the lagoon. The County and its partners teamed with several consultants to develop the Spatial Watershed Iterative Loading (SWIL) model that revised the estimates of loading by source to the lagoon (refer to **Section 2** for more details) and to update the TMDLs. The loading estimates and TMDL targets referenced in this plan are from these efforts, as they are based on the most up-to-date data and analyses.

Damage to the lagoon has been occurring for decades and will require time and money to reverse. An important example is the accumulation of muck on the bottom of 10% of the IRL. This muck kills marine life and releases stored pollutants into the IRL. To address the damage to the IRL system, in 1990, Brevard County implemented a stormwater utility assessment, which established an annual assessment rate of $36 per year per equivalent residential unit (ERU) that stayed at this level until 2014. The rate increased to $52/ERU for 2014 and 2015, and increased to $64/ERU in 2016. This raised collections from $3.4 million (in 2014) to $6.0 million (projected for 2016). Of the funding raised, a portion is available for capital improvement programs or other stormwater best management practices (BMPs), and is split between water quality improvement programs and flood control and mitigation programs. In addition, funding is spent on annual program operating expenses. Operation and maintenance includes National Pollutant Discharge Elimination System permit compliance activities (street sweeping, trap and box cleaning, and aquatic weed harvesting), outfall/ditch treatments, small scale oyster restoration, as well as harvesting and replanting of floating vegetative islands.

While revenues from this stormwater assessment, over the last 10 years, have funded many projects, a significant portion of projects have been partially funded by grants. When applicable, federal water quality grants provide up to 60% matching funds, state TMDL grants provide up to 50% match, and SJRWMD cost-share grants fund up to 33% of construction. All of these grant programs are highly competitive and subject to variable state and federal appropriations, as well as changing priorities.

Due to funding limitations and the continuing degradation of key indicators of health in the IRL, such as seagrass and fish, Brevard County identified a need for additional funding to implement projects identified as critical to lagoon restoration. Therefore, the County placed a Save Our Indian River Lagoon ½ cent sales tax referendum on the ballot in November 2016. This referendum passed by more than 60% of the votes and will provide a funding mechanism for the projects listed in this plan (or future annual updates) for the County and its municipalities. Revenue collection from the sales tax began in January 2017.

This Save Our Indian River Lagoon Project Plan outlines projects planned to meet updated TMDL targets and improve the health, productivity, aesthetic appeal, and economic value of the lagoon. Almost all of these projects require sales tax funding in order for these projects to be implemented. Furthermore, the local sales tax funding could be used to leverage significantly more in match funding from state and federal grant programs. The IRL ecosystem is an asset valued not only in Florida but also nationally; therefore, implementation of this plan would help to restore this national treasure. If additional funding is provided through matching funds from other sources, additional projects may be implemented, which would increase the overall plan cost, and/or project timelines may be moved up to allow the benefits of those projects to occur earlier than planned. Response of the lagoon ecosystem may lag for several years behind completion of nutrient reduction implementation; however, action must be accelerated now to ensure restoration succeeds over time.

1.1. Return on Investment and Economic Value

The economic value of the lagoon system was evaluated during development of this plan. It was estimated that at least a total present value of $6 billion is tied to restoration of the IRL. There is approximately $2 billion in benefits from restoration and an estimated $4 billion in damages if the IRL is not brought back to health during the next decade.

If viewing this project plan purely as a financial investment that pays the $2 billion in benefits alone (i.e. not counting the avoidance of the $4 billion loss), the projected pretax internal rate of return is 10%, if the plan takes 20 years to implement. However, if the County were to bond the sales tax revenue to accelerate implementation of this plan over 5 years instead of 20 years, the return on investment rises significantly to 26% because the benefits of restoration would begin to accrue much faster. Based on the sensitivity of the rate of return to the speed of plan implementation, it would be financially responsible and beneficial for the County to borrow money at a typical 4% annual bond rate in order to accelerate implementation in order to achieve the 26% return on investment. In annualized terms, borrowing $300 million at 4% to achieve a steady 26% annual return would contribute $63 million in annual positive cash flow; making bonding an excellent investment choice.

Table 1 documents projections of three economic engines likely to have significant economic impacts on Brevard County residents with positive impacts if the IRL is restored versus negative impacts if the IRL is not restored. Additional detail on each of these impacts is provided in **Section 1.1.1**. The upper part of the table lists the economic benefits for restoring a healthy IRL while the lower part of the table lists the economic costs of declining IRL health in the absence of restoration through plan implementation.

Economic impacts in the table are expressed both as annual cash flows and as the discounted expected present value of those cash flows over a 30-year financial plan period. Expected present value is an economic indicator used in business to express the present monetary value of a future stream of cash flows. This expected monetary value discounts the future stream by an interest rate and also discounts it further by a probability factor to account for the uncertainty of future events. Therefore, the expected present value of IRL economic benefits shown in **Table 1** is much less than the sum of those future cash flows.

Table 1: Economic Impact Scenarios Based Upon the Condition of the IRL

Economic Benefits for Restoring a Healthy IRL	Annual Cash Flow	Expected Present Value
Tourism and Recreation Growth	$95 million	$997 million
Property Value Growth	$81 million	$852 million
Rebirth of Commercial Fishing (excludes indirect benefits)	$15 million	$159 million
Healthy Residents and Tourists	Not quantified	Not quantified
Total Benefits	***$191 million***	***$2.01 billion***
Economic Costs of Declining IRL Health	**Annual Cash Flow**	**Expected Present Value**
Tourism and Recreation at Risk	-$237 million	-$3 billion
Property Value at Risk	-$92 million	-$1.2 billion
Decline of Commercial Fishing (excludes indirect impacts)	-$6 million	-$87 million
Potential Pathogen Impacts to Residents and Tourists	Not quantified	Not quantified
Total Damages	***-$335***	***-$4.29 billion***

Today there is a $6 billion decision point for the IRL. Despite unprecedented algae blooms and fish kills, conditions could become worse. If large-scale fish kills continue with increasing frequency, algae blooms continue or become toxic, or there is a pathogen outbreak, then real estate, tourism, and the quality of life and health for Brevard County residents would likely suffer.

1.1.1 Areas of Economic Value at Risk

Tourism and Recreation

Today's tourism revenue in Brevard County comes primarily from the beaches. In order to diversify the tourism base and increase revenue, Brevard County has developed a plan to increase ecotourism, a globally growing and high value sector of tourism that depends on restoration and maintenance of a healthy IRL. High value ecotourism relies on exceptional natural experiences including fishing, bird watching, kayaking, paddle boarding, camping, hiking, and nature tours. In the short-term, there are opportunities for tourists to participate in restoration experiences, such as collecting mangrove seeds by kayak or canoe, planting mangrove seedlings, or establishing colonies of clams, oysters, or mussels. A successful example of Brevard County ecotourism is the world famous annual Space Coast Birding and Wildlife Festival that brings $1.2 million annually to the County and attracts approximately 5,000 visitors.

Property Value

While the economic benefits of IRL restoration are likely to increase property value throughout the County, to be conservative this plan assessed the exposure only to properties with frontage on Mosquito Lagoon, IRL, Banana River Lagoon, Sykes Creek, and connected waterways. Approximately 11.2% of the County's $27 billion in taxable property value is directly on the IRL. Therefore, more than $3 billion in taxable property value is directly at risk with ongoing IRL issues, such algal blooms and fish kills. Furthermore, a weighted-average millage rate of 18.58 results in an estimated annual tax revenue of $56 million that is also at risk in the absence of IRL restoration. The $852 million of incremental expected present value assumes a 20% improvement in IRL frontage property value, which would be 90% likely after 10 years with the IRL restored.

Consultants for the County surveyed the Space Coast Association of REALTORS® to assess the likely impacts of IRL health on the waterfront property value. Approximately 170 REALTORS® most familiar with the waterfront market replied to the survey. These professionals assessed that waterfront IRL property values would increase 22% on average over five years if the IRL were healthy and would decrease by 25% over five years if the lagoon were not restored.

Commercial Fishing

IRL restoration is critical to the recovery of a once thriving, valuable, and world-class fishery, both commercial and recreational. In 1995, the commercial fish harvest in Brevard County was $22 million annually. While a 1995 ban on commercial net fishing marked economic decline, the degradation of the lagoon system contributed considerably to a severe reduction in value of only $6.7 million annually in 2015, based on Florida Fish and Wildlife Conservation Commission (FWC) data (see **Figure 1**). These numbers do not include the many indirect benefits of a robust commercial fishing industry including fresh local fish for restaurants, employment, commerce of supplies and services for the industry, and benefits of local fresh fish for residents and visitors.

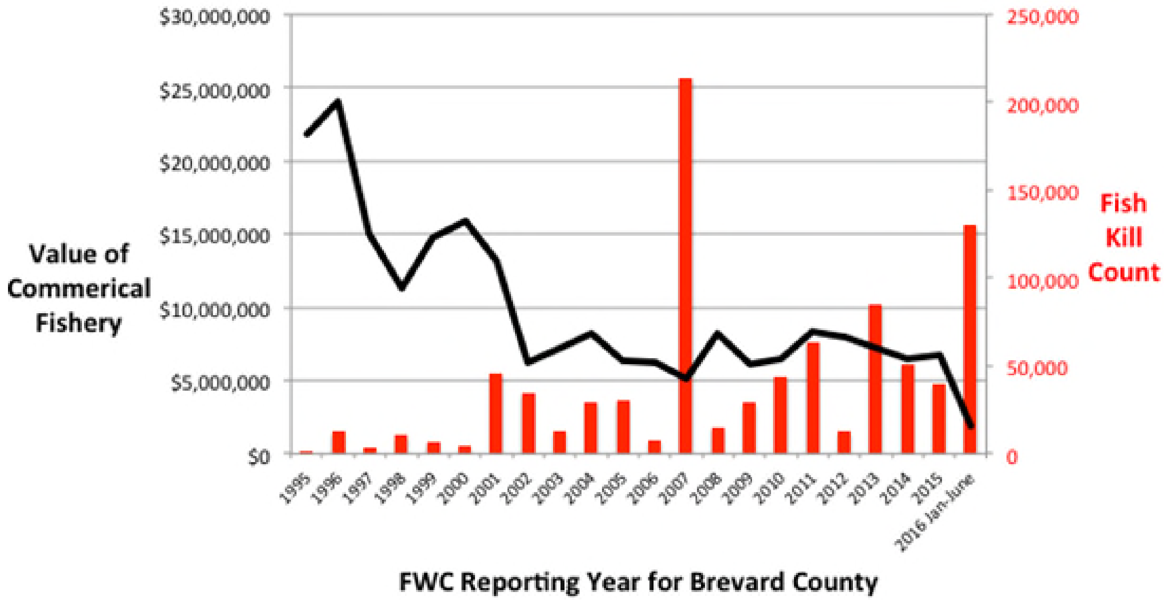


Figure 1: Decline of Commercial Fishing and Increasing Fish Kill Severity

In addition, a healthy fish population is critical to the brand of any coastal community. Historically Brevard County was once home to a world-class abundance and diversity of rare and widespread species of fish, crabs, shrimp, and clams that made the IRL a global brand. That brand can be restored along with the fish and shellfish of the IRL.

Healthy Residents and Tourists

There are almost 82,000 permitted septic systems within Brevard County, of which nearly 59,500 septic systems pollute groundwater that migrates to the lagoon. This groundwater moves slowly toward the lagoon through soils that attenuate some but not all of these pollutants. It would cost at least $1.19 billion to convert all 59,500 septic tanks to central sewage treatment. While total conversion is cost prohibitive, this plan targets the septic systems with the highest potential impacts to the lagoon. Targeted action includes connection to the central sewer system or upgrade to advanced treatment systems that remove significantly more nutrients and pathogens than traditional septic systems.

Although there are studies that have identified pathogens migrating from septic systems into waterways, it is not possible to estimate the economic impact of potential disease from these waterborne pathogens. The conversion of septic systems is expensive relative to other types of nutrient reduction projects; however, the additional health benefits associated with septic system upgrades make this option a priority beyond only the abatement of nutrients.

1.2. Maximizing Benefits and Managing Risk

There is much at stake with regard to both economic outcomes and the incremental funding critical to restoration; therefore, the County chose to address the unavoidable risks inherent in a multi-year, large-scale restoration plan in a transparent and objective manner. To help ensure objectivity, the County retained outside consultants to assess risk and to estimate potential positive or negative outcomes.

The approach for this plan to evaluate the different project options included using Expected Monetary Value (EMV) models; a decision science tool used in business to improve decision-making and planning in a context of unavoidable uncertainty. EMV is a financial model of probability-weighted outcomes expressed in quantified financial terms that are comparable across multi-year planning periods. To compare outcomes, expected present value was used as a key metric. Expected present value has the benefit of valuing future financial costs and benefits in common present day terms to take into account the value of time and to facilitate comparisons of initiatives spanning long periods of time.

As part of this methodology, consultants engaged Subject Matter Experts to assess the uncertainties of project scenarios. Subject Matter Experts include scientists, property value experts, tourism experts, lagoon advocates, and agency staff. Subject Matter Experts brought expertise in IRL science, nutrient reduction technologies, waterborne pathogens, and relevant law or county financial and accounting parameters needed for the EMV models. Information gathered during these assessments was used to document the key interdependence of initiatives, minimize risk, and maximize the likely return on investment.

1.2.1 Project Selection to Maximize Return on Investment

Assessment of risk by Subject Matter Experts determined that the amount and speed of nutrient reductions are the two most critical factors affecting the success of restoring IRL health. Therefore, those projects with the greatest nutrient reduction benefit for the least cost are recommended for funding and, of those, the projects with the greatest benefits are planned for implementation first. Three other key criteria drove this plan:

1. Achieving sufficient nutrient abatement through a blend of options was a key success factor for restoration.
2. No one type of project alone could achieve an adequate nutrient abatement.
3. The target for nutrient reduction must be sufficient to minimize the need for recurring expensive muck removal, which is important for future cost avoidance.

The plan sequences a diversity of project types, implementing the highest nutrient reduction impact early and implementing other projects concurrently in order to achieve a multi-pronged blend of total nutrient abatement as quickly as possible with minimal risk. Another important consideration for project sequencing was how quickly projects could produce significant nutrient pollution reduction. For decades, man-made nutrient pollution from fertilizers, septic systems, and stormwater runoff have been introduced at varying distances from the IRL. The soils are still saturated with those nutrients. Therefore, if all sources of nutrient pollution ended today, groundwater would continue to transport nutrients accumulated in the soil into the IRL with every rain event for decades in the future. However, soils next to the IRL will purge themselves quickly, in days or weeks. Septic system conversions near the lagoon or near drainage conduits into the lagoon are likely to produce water quality and reduced pathogen benefits in the lagoon in weeks or months whereas septic conversions more distant from waterways are not anticipated to generate lagoon benefits for several decades. Therefore, whenever possible, project selection and sequencing scheduled nutrient abatements closest to the IRL first.

Undoing the damage to a unique and complex biological system as large as the IRL carries inherent risk. The County made the decision to be open and transparent about that risk. Assessing that risk diligently has allowed the County to mitigate and manage risk proactively in the development of this plan.

Two subjective risk assessments were conducted by an independent consultant working with top science Subject Matter Experts most knowledgeable about the IRL. The first assessment was conducted with individual Subject Matter Experts and occurred before plan projects were defined. These experts assessed that the likelihood of a healthy fish population in the IRL would begin to rise faster after reaching a critical point of nutrient reduction. Therefore, there is a "critical mass" of nutrient reduction needed to achieve significant and sustainable IRL health benefits. The Subject Matter Experts also assessed that the likelihood of recovery would continue to improve as more nutrients are removed from the IRL and then begin to decline if too many nutrients were removed. The result of that first risk assessment reinforced the objective of reducing nutrients in the IRL as quickly as possible through the definition and sequencing of the projects in this plan.

A second uncertainty assessment was conducted in a meeting at the Florida Institute of Technology with a group of water quality, toxicity, muck, fish, algae, invertebrates, and seagrass Subject Matter Experts. First, the experts were briefed about the projects proposed in this plan. The experts were then asked their subjective assessment of the likelihood of a healthy lagoon after this plan was implemented in each sub-lagoon. Sub-lagoons were assessed because the experts had commented previously that each sub-lagoon functioned differently. This group assessment indicated higher likelihoods of success than the first assessment. However, the scientists continued to voice concern about the restoration of the IRL in the absence of regulatory reform needed to prevent new development from adding more septic system and stormwater pollution to the lagoon. Therefore, updated regulations are needed as a complement to this plan to ensure timely and sustained success in restoring health to the IRL.

Figure 2 represents the input from the Subject Matter Experts.

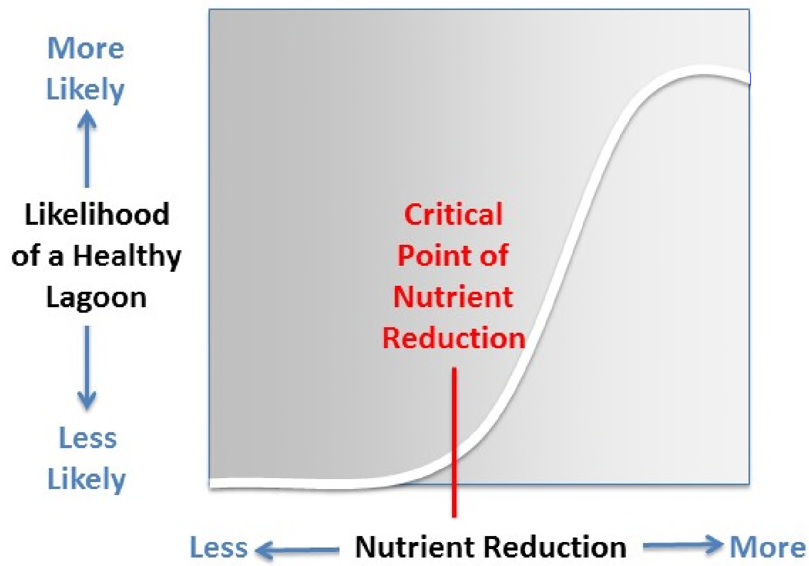


Figure 2: Likelihood of a Healthy IRL as Nutrients are Removed

There are other large-scale aquatic system restoration efforts that have been successful in achieving restoration. Some of these systems were damaged even more so than the IRL, but they have recovered through the implementation of extensive, multi-year, and multi-pronged restoration plans. These include the Chesapeake Bay, Cuyahoga River, Lake Erie, and Tampa Bay. These areas have reaped enormous economic and quality of life benefits as a result of dedicated investments in their restoration.

Section 2. Approach

The amount and distribution of nutrient loading from the sources described in **Section 3** were examined to determine the key locations where nutrient reduction projects are needed and the extent of reductions required from each source to achieve the County's proposed TMDLs for each sub-lagoon. For each source, a reduction goal is set and projects are proposed to meet the goal. The estimated cost for each project is also included. Information on expected project efficiencies and project costs were gathered from data collected by the County in implementation of similar projects, as well as literature results from studies in Florida, where available, and across the country. The most cost-effective projects are selected and prioritized to maximize the nutrient reductions that can be achieved.

2.1. Plan Focus Area

This plan focuses on projects implemented in three sub-lagoons in the IRL system: Banana River Lagoon, North IRL, and Central IRL. **Figure 3** shows the locations of these sub-lagoons. All of the Banana River Lagoon watershed and the majority of the North IRL watershed are located within Brevard County. However, only a portion of the Central IRL watershed is located within the County. As shown in **Figure 3**, Central IRL Zone A is located entirely in Brevard, whereas Zone SEB straddles Brevard and Indian River Counties. For Zone SEB, the County has completed several projects in this area and SJRWMD is completing projects along the C-54 Canal and on the Wheeler property to treat the Sottile Canal. The reductions from these projects should be sufficient to meet the required reductions in the Brevard County portion of Zone SEB, as shown in **Table 2**. This plan includes some additional beneficial projects located in Zone SEB to help ensure that the necessary reductions are achieved throughout Brevard County; however, the majority of projects proposed in this plan for the Central IRL fall within Central IRL Zone A.

Table 2: Summary of Load Reductions and Projects in Central IRL Zone SEB

Category	TN Load (lbs/yr)	TP Load (lbs/yr)
Stormwater and Baseflow Loading	248,233	34,901
Atmospheric Deposition Loading	22,371	404
Point Sources Loading	0	0
Total Loading	270,604	35,305
5-month TMDL Percent Reductions	38.0%	35.0%
Required Reductions	***102,830***	***12,357***
Completed County Projects (2010-February 2016)	29,890	9,643
C-54 Project	65,974	10,558
Wheeler Property Project	36,582	21,784
Total Project Reductions	***132,446***	***41,985***
% of Required Reductions Achieved	***128.8%***	***339.8%***

In addition, a small portion of the County is located within the Mosquito Lagoon. Brevard County does not have stormwater outfalls, septic systems, or point sources in this sub-lagoon. However, this plan includes a muck removal project within Mosquito Lagoon.

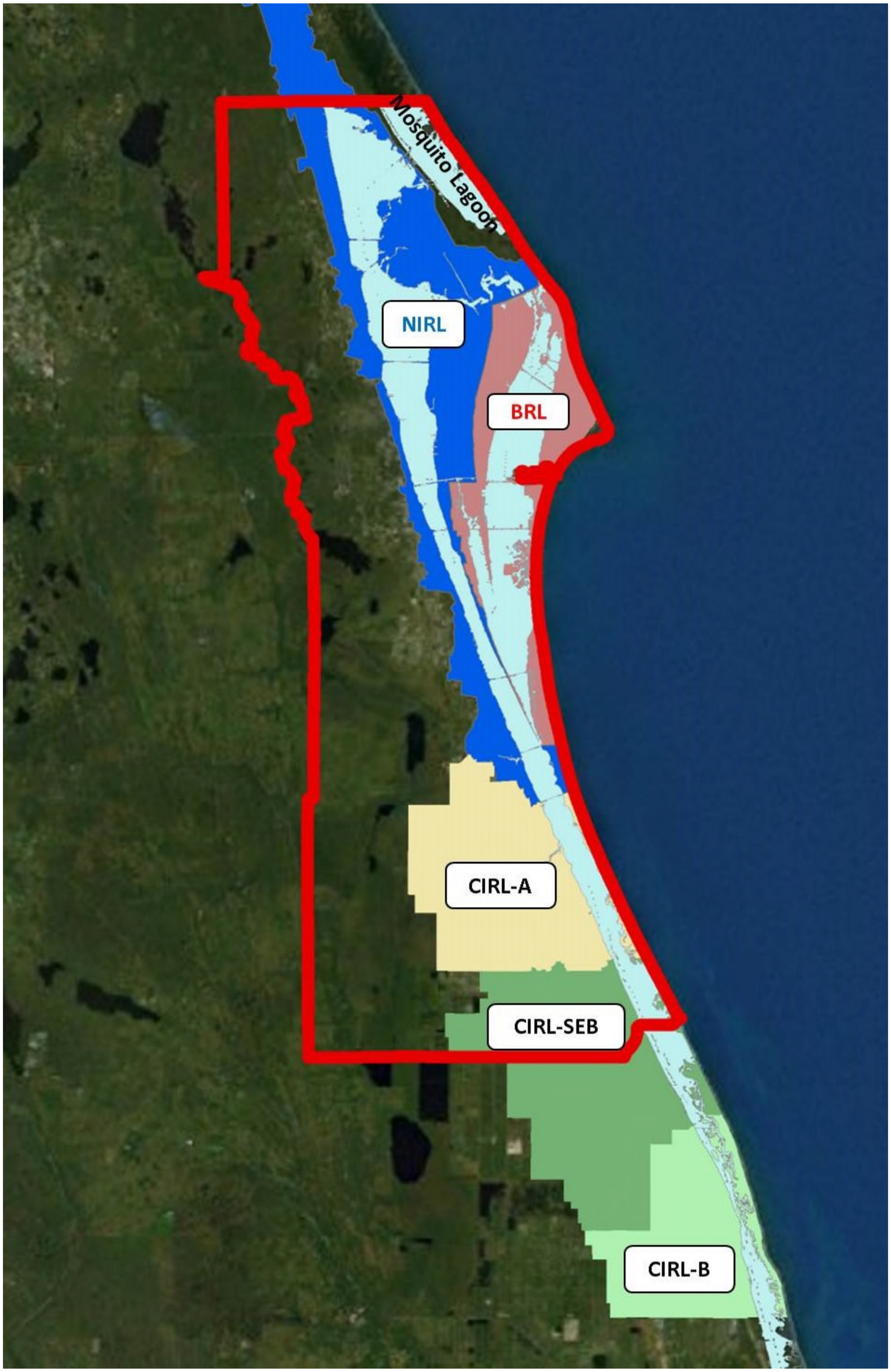


Figure 3: Locations of the Banana River Lagoon (BRL), North IRL (NIRL), and Central IRL (CIRL) Sub-Lagoons

Section 3. Pollutant Sources in the IRL Watershed

Pollutant loads in the IRL watershed are generated from multiple external sources that discharge to the lagoon. Excess loads also accumulate in nutrient sinks within the lagoon, which release nutrients to the water column during certain conditions.

External sources fall into the following major categories:

- Stormwater runoff that occurs when rainfall hits the land and cannot soak into the ground:
    - Urban stormwater runoff is generated by rainfall and excess irrigation on impervious areas associated with urban development. Urban runoff picks up and transports nutrient loading from fertilizers, grass clippings, and pet waste, as well as other pollutants including sediments, pesticides, oil, and grease. Stormwater ponds and baffle boxes reduce the nutrient loading in stormwater; however, proper maintenance of these systems is necessary to maintain their performance.
    - Agricultural stormwater runoff occurs on agricultural land and this runoff also carries nutrients from fertilizers, as well as livestock waste, pesticides, and herbicides. This source of stormwater runoff is not addressed in this plan as the County does not have jurisdiction over agricultural use. The Florida Department of Agriculture and Consumer Services (FDACS) has an agricultural BMP program, and they work with agricultural producers to control the loading from this source.
    - Natural stormwater runoff comes from the natural lands in the basin. This source is not addressed by this plan as natural loading does not need be controlled.
- Baseflow is the groundwater flow that contributes loading to the IRL. Due to the sandy soils in the basin and excess irrigation, nutrients can soak quickly into the groundwater with little removal. This groundwater can recharge surface water in ditches, canals, tributaries, or the IRL.
    - Excess fertilizer that soaks into the ground past the root zones.
    - Septic systems, both functioning and failing, contribute nutrient loading to the groundwater.
    - Leaking sewer pipes located above the water table can contribute nutrient loading to the groundwater.
- Atmospheric deposition that falls on both the land and the lagoon itself:
    - Nutrients in the atmosphere fall into the basin largely during rainfall events. The sources of these nutrients are from power plants, cars, and other sources that burn fossil fuels. However, because of atmospheric conditions and weather patterns, not all of the nutrients from atmospheric deposition are generated within the watershed. Atmospheric loading is not directly addressed by this plan as air quality and air emission standards are regulated by the federal Clean Air Act and are not within the County's control. However, the stormwater projects and in-lagoon projects will treat some of the nutrient loading from atmospheric deposition that falls on the land and lagoon surface.
- Point sources that treat collected sewage and discharge treated effluent:
    - The direct WWTF discharges to the lagoon have been largely removed, and the majority of facilities in the basin use the treated effluent for reclaimed water irrigation. However, depending on the level of treatment at the WWTF, the reclaimed water can have an excessive concentration of nutrients that may contribute loading to the baseflow.
    - There have been issues with inflow and infiltration into the sanitary sewer collection system. Large rain events can result in large amounts of water entering the sewer

collection system, and this additional water can cause sewer overflows that contribute nutrients and bacteria to local waterbodies.

In addition to these external sources of loading to the lagoon, nutrients from muck (muck flux) is an internal source of loading within the lagoon itself. Muck is made up of organic materials from soil erosion on the land and from decay of organic matter (leaves, grass clippings, algae, and aquatic vegetation) in the lagoon. As these organic materials decay, they constantly flux nutrients into the water column above, where they add to the surplus of nutrients coming from external sources.

Table 3 summarizes the estimated loading from these sources in the Banana River Lagoon, North IRL, and Zone A of the Central IRL. The stormwater runoff and baseflow/septic systems loading estimates are from the SWIL model, the point source loading estimates were based on the facility monthly operating reports and discharge monitoring reports, and the atmospheric deposition loads are from measured data at nearby stations. The muck flux load estimates are calculated based on the muck area in each portion of the lagoon and flux estimates from studies in the lagoon (refer to **Section 4.2.1** for more details). The loading from these sources is also shown graphically in **Figure 4, Figure 5**, and **Figure 6**.

Table 3: Loading from Different Sources in Each Sub-lagoon

Source	Banana River Lagoon (with canals)		North IRL		Central IRL Zone A	
	TN (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)
Stormwater Runoff	119,923	15,064	328,047	45,423	279,351	43,193
Baseflow/Septic Systems	164,225	22,613	344,112	47,383	370,130	50,966
Atmospheric Deposition	175,388	3,222	301,977	5,505	49,456	892
Point Sources	17,484	3,370	14,711	1,029	0	0
Muck flux	705,561	106,771	478,824	71,824	42,500	6,250

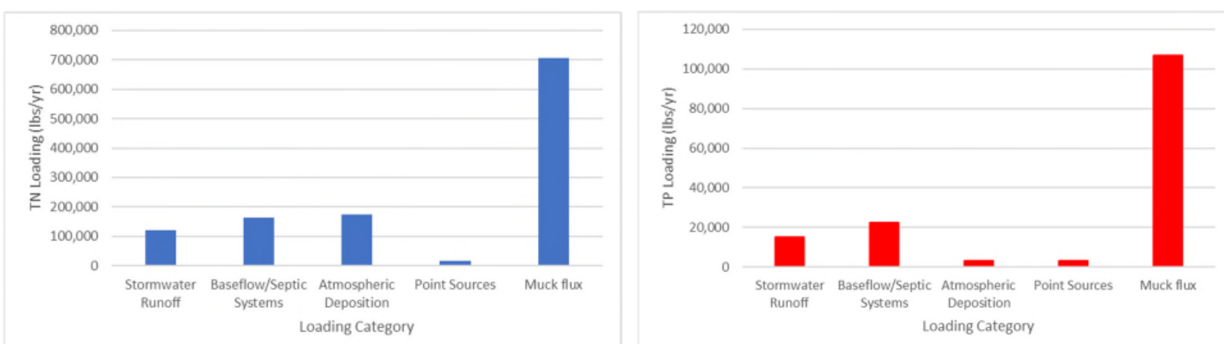


Figure 4: Banana River Lagoon TN (left) and TP (right) Annual Average Loads by Source

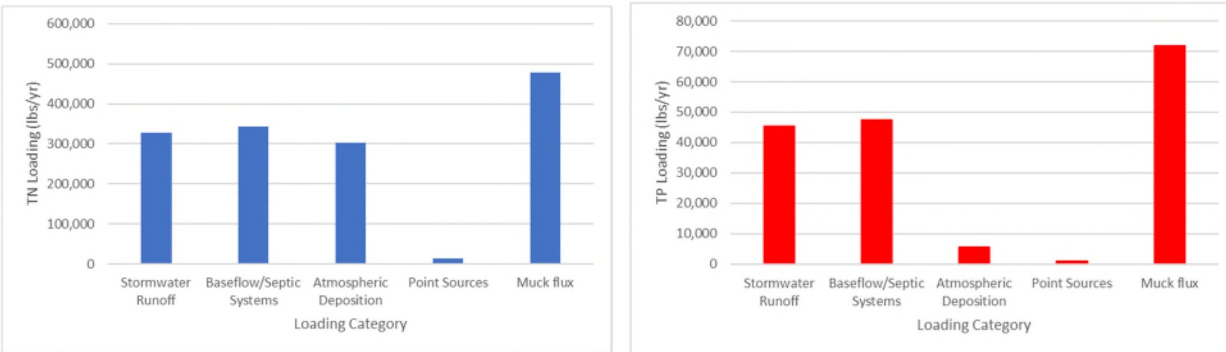


Figure 5: North IRL TN (left) and TP (right) Annual Average Loads by Source

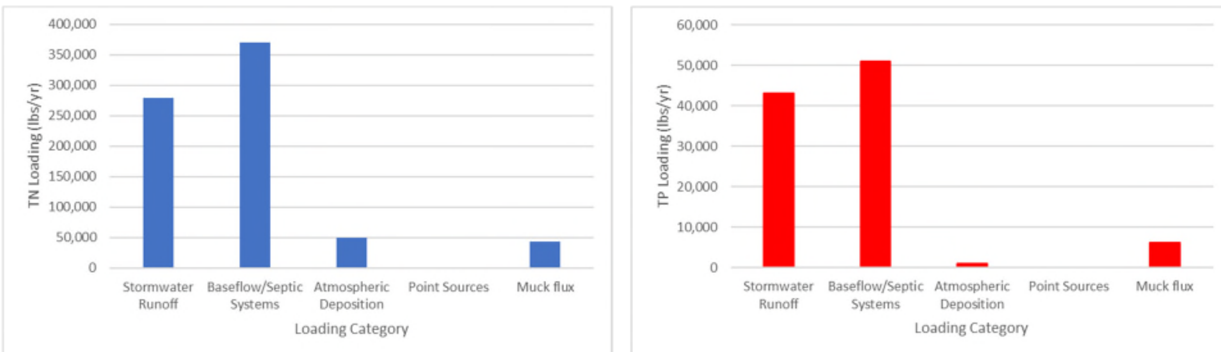


Figure 6: Central IRL TN (left) and TP (right) Annual Average Loads by Source

Section 4 includes information on projects to reduce the loading from urban stormwater runoff (including fertilizers and grass clippings), reclaimed water from WWTFs, and septic systems; to remove the internal cycling of loads accumulated in the muck deposits; and to restore natural filtration processes.

Section 4. Project Options

In order to restore the lagoon's balance, Brevard County has been implementing a multi-pronged approach to **Reduce** pollutant and nutrient inputs to lagoon, **Remove** the accumulation of muck from the lagoon bottom, and **Restore** water-filtering oysters and related lagoon ecosystem services. This plan also recommends funding for project monitoring, needed for accountability and to **Respond** to changing conditions and opportunities. Response funds will be used to track progress, measure cost effectiveness, and report on performance. Each year, a Citizen Oversight Committee (additional details are included in **Section 4.4.1**) will review monitoring reports and make recommendations to the Brevard County Board of County Commissioners to redirect remaining plan funds to those efforts that will be most successful and cost-effective. Although research is important to better understand factors that significantly impact the health, productivity, and natural resilience of the IRL, funding for research is not included in this project plan.

Several goals were set to help select the projects for this plan. The goal for the **Reduce** projects is to achieve the proposed five-month TMDL for each sub-lagoon (refer to **Section 5** for additional details on the TMDLs). The goal for the **Remove** projects is to achieve at least a 25% reduction in estimated recycling of internal loads. The goals for the **Restore** projects are to filter the entire volume of the lagoon annually and to reduce shoreline erosion. The most cost-effective projects in each category were selected to maximize nutrient reductions, minimize lag time in lagoon response, reduce risk, and optimize the return on investment.

Section 4.1 through **Section 4.4** provide information on the proposed projects, estimated nutrient reduction benefits, and costs, as well as the ongoing research needed to measure and assess the project efficiencies and benefits to the lagoon system.

4.1. Projects to Reduce Pollutants

An important step in restoring the lagoon system is reducing the amount of pollutants that enter the IRL through stormwater runoff and groundwater. Reduction efforts include source control (such as fertilizer reductions) to reduce the amount of pollutants generated, as well as treatment to reduce pollutants that have already been discharged before they are washed off in stormwater runoff or enter the groundwater system and ultimately discharge to the IRL. Monitoring of these projects will be performed to verify the estimated effectiveness of each project type implemented (refer to **Section 4.4**).

The benefits from fertilizer management and public education, WWTF upgrades for reclaimed water, and stormwater treatment are seen fairly quickly in the lagoon system. Public education about fertilizer and other sources of pollution addresses nutrients at their source and prevents these nutrients from entering the system. WWTF upgrades result in reduced nutrients in the treated effluent, which is then used throughout the basin for reclaimed water irrigation. The stormwater projects will capture and treat runoff, which is currently untreated or inadequately treated, before it reaches the lagoon.

While greatly beneficial, septic system removal or upgrade projects may take longer to result in a nutrient reduction to the lagoon. The septic systems in key areas must be removed or upgraded in order to see the full benefits. In addition, septic systems contribute nutrient loading to the lagoon through groundwater, and the travel time of the nutrient plumes through the groundwater to a waterbody vary throughout the basin depending on watershed conditions.

The following subsections summarize the fertilizer management and public education, septic system removal and upgrades, WWTF upgrades for reclaimed water, and stormwater treatment projects that will be implemented to reduce nutrient loads to the IRL.

4.1.1 Public Outreach and Education

Fertilizer Management

Approximately 81,700 lbs/yr of TN and 4,200 lbs/yr of TP enter the lagoon watershed from excess fertilizer application.

It is a common practice to apply fertilizer on urban and agricultural land uses. However, excessive and inappropriately applied fertilizer pollutes surrounding waters and stormwater. FDACS compiles information on the fertilizer sales by county, as well as the estimated nutrients from those fertilizers. It is important to note that all fertilizer sold in a county may not be applied within that county because a portion of that fertilizer may be transported to another county. However, details on the amount of fertilizer transported between counties is not tracked. Therefore, the information in the FDACS reports is simply the best estimate of the amount of fertilizer used, and the associated nutrient content, in a county.

Table 4 and **Figure 7** summarize the nutrients in the lawn fertilizer sold in Brevard County, according to FDACS records. This information was organized by fiscal year. The figure shows a decrease in the amount of nitrogen and phosphorus fertilizer being sold in the County after the fertilizer ordinance was adopted in 2013.

Table 4: Nutrients in Lawn Fertilizer Sold in Brevard County by Fiscal Year

Fiscal Year	Lawn Fertilizer Nitrogen (tons/yr)	Lawn Fertilizer Nitrogen (lbs/yr)	Lawn Fertilizer Phosphorus (tons/yr)	Lawn Fertilizer Phosphorus (lbs/yr)
2012-2013	1,673	3,346,140	61	122,740
2013-2014	319	637,700	63	126,400
2014-2015	204	408,220	16	32,520

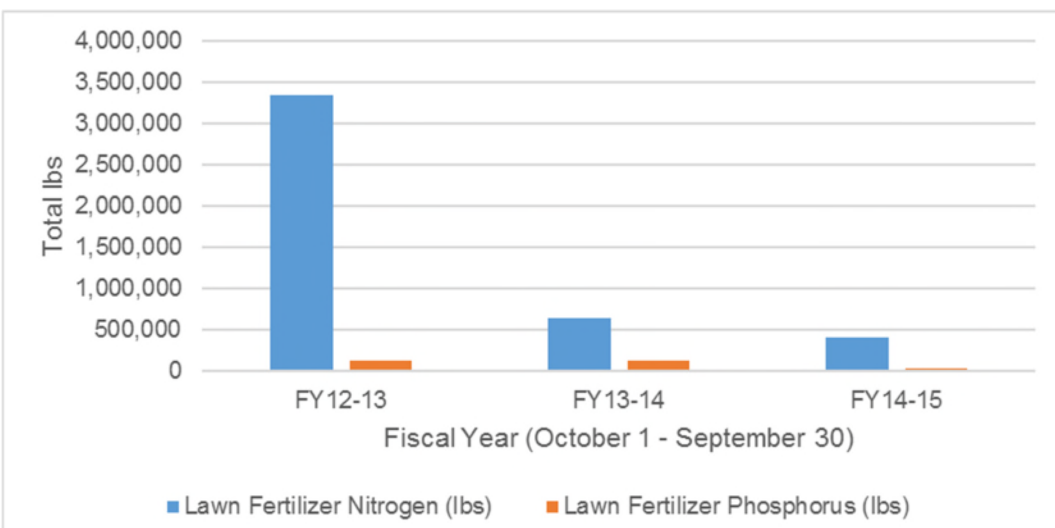


Figure 7: TN and TP in Lawn Fertilizer Sold in Brevard County by Fiscal Year

To help address fertilizer as a source of nutrient loading, local governments located within the watershed of a waterbody or water segment that is listed as impaired by nutrients are required to adopt, at a minimum, FDEP's Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes (Section 403.067, Florida Statutes). Brevard County and its municipalities adopted fertilizer ordinances that included the required items from the Model Ordinance in December 2012, as well as additional provisions in 2013 and 2014. The County's fertilizer ordinance is found in Chapter 46, Article VIII, Section 46-335 through Section 46-349. This ordinance "regulates and promotes the proper use of fertilizers by any applicator; requires proper training of commercial and institutional fertilizer applicators; establishes training and licensing requirements; establishes a prohibited application period; specifies allowable fertilizer application rates and methods; fertilizer-free zones; low maintenance zones; and exemptions. The Ordinance requires the use of best management practices which provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of fertilizers."

The County's ordinance prohibits the application of fertilizer that contains nitrogen and/or phosphorus during the period of June 1 through September 30, as well as when heavy rain is likely (including a watch or warning for a flood, tropical storm, or hurricane). Fertilizer application is also prohibited within 15 feet of any surface waterbodies, to limit the likelihood that fertilizer will run off into a waterbody. Fertilizer applied within the County must not contain phosphorus, unless a soil or plant tissue test indicates a need. Fertilizer with nitrogen should contain at least 50% in the form of slow release, controlled release, timed release, slowly available, or water insoluble nitrogen. When applying fertilizer, the ordinance requires deflectors on broadcast spreaders and removal of any fertilizer spilled on an impervious surface, which can then runoff into the stormwater system.

The ordinance also requires grass and vegetation clippings not to be swept, washed, or blown off into surface waterbodies or the stormwater system. Commercial applicators, must complete a training program and carry evidence that they have completed the training. The ordinance only applies to use of urban fertilizer, and not fertilizer applied to a bona fide farm operation.

In addition to the fertilizer ordinance, Brevard County, nine municipalities, Good Education Solutions, and the Brevard Zoo created a public education campaign called "Blue Life" in 2012. The purpose of this campaign is to provide information to the public about sources of pollution and what actions people can take to protect and improve water quality. The campaign is a combination of public service announcements; TV, radio, and billboard advertisements; social media; community forums and talks; workshops; school programs; and other printed informational materials. The information includes details on fertilizer and pesticide use and management, proper lawn and garden maintenance, pet waste management, proper car washing and maintenance, waste management, and litter control.

To determine the effectiveness of this educational campaign on behavior changes, the County contracted with Praecipio Economics Finance Statistics (PEFS) to conduct a survey before the campaign implementation in 2012 and after the campaign was in place for two years in 2015. A similar survey was used in both 2012 and 2015, although the 2015 survey included additional questions about the Blue Life campaign, fertilizer bans, and state of the IRL. The survey was mailed to about 50,000 households who receive water from the City of Melbourne utility. A total of 1,470 usable surveys were obtained for 2012 and 1,572 usable surveys were obtained for 2015. The results were tabulated and analyzed to compare the pre- versus post-Blue Life campaign responses (PEFS 2016).

When comparing the results from the 2012 and 2015 surveys, PEFS (2016) found that the study unambiguously showed that people in 2015 were better informed about stormwater issues than in 2012, and that behavior that affects water quality in the area has, in general, improved:

- The 2015 population received more information about stormwater runoff and were better informed about stormwater runoff issues. The proportion of respondents who received “a lot” or “some” information about stormwater runoff issues increased by 6% and 19%, respectively. Perceptions about water quality became much more negative, increasing by 10% for “very poor” and 18% for “poor.” Lawn and garden fertilizer was identified as the single biggest source of water pollution by 7.6% more respondents.
- Significant improvements in behavioral traits associated with lawn maintenance (lawn clippings, fertilizer application, pesticide application, frequency of fertilizer applications, and fertilizer types) occurred between 2012 and 2015. The percentage of people who leave the lawn clippings on their grass after it is mowed rose by 3.5% (from 77% in 2012). The percentage of people who report that they do not apply fertilizer and/or pesticides increased by 6.4% and 6.5%. Of those who do fertilize their lawns, the proportion who fertilize their lawn once or twice a year rose by 5.3%. Persons who used desirable fertilizer types (no phosphorus, slow release, and/or dry/granulated fertilizer) rose by 7.6%.
- Significant improvements in where a vehicle is washed and the pickup of dog waste occurred between 2012 and 2015. There was a 5.1% increase in the proportion of people who take their vehicle to a commercial car wash (instead of washing their car at home) and a 5.9% increase in the proportion of people who “always” pick up their dog’s waste.

PEFS (2016) also included an evaluation of the 2015 survey results for those people who were exposed to the Blue Life campaign versus those who had not seen campaign materials. The people who were exposed to the Blue Life campaign were more familiar with the environmental problems of the IRL and were knowledgeable about the fertilizer ordinances:

- People in the Blue Life subgroup reported greater familiarity with the pollution problems in the IRL (17.4% higher) and recently enacted fertilizer ordinances (11.6% higher) than persons in the non-Blue Life subgroup.
- About 25% of the 2015 sample population remembered being exposed to Blue Life promotional materials, with water bill inserts and farmer’s market outreach representing the two largest pathways.

The results of the surveys show that the Blue Life campaign, as well as other educational efforts in the County, had a beneficial impact on people’s behaviors and knowledge of the IRL problems. Continuation of this campaign, or other similar public education and outreach efforts, would have a benefit in reducing sources of the pollution to the lagoon (fertilizers, pesticides, pet waste, oil and grease from cars).

The County, city, and grant funding spent on the Blue Life campaign is summarized in **Table 5**. This funding helped contribute to the results seen in the survey.

Table 5: Brevard County Funding for the Blue Life Campaign by Fiscal Year (FY)

FY (October 1 – September 30)	Costs
2012-2013	$83,124
2013-2014	$112 812
2014-2015	$182,482
Total	***$378,418***

The Blue Life campaign is continuing its education and outreach efforts including digital billboards (see **Figure 8**), radio advertisements, *Florida Today* sticky note (see **Figure 9**), and water bill insert for the City of Cocoa and City of Melbourne customers.

Figure 8: New Blue Life Digital Billboard

Figure 9: *Florida Today* Sticky Note

The University of Florida (UF) Institute of Food and Agricultural Sciences (IFAS) Extension Office in Brevard County also implements programs and activities that focus on proper fertilizer application and water quality/conservations measures. The anticipated outcomes of these programs are that participants will gain knowledge, and most importantly, will adopt practices that result in behavior change.

Two horticultural faculty plan, implement, and evaluate the Florida Friendly Landscaping™ program, which includes the following:

> My Brevard Yard – This is a hands-on program delivered through classroom training and/or one-on-one onsite consultations. In the classroom training, participants learn about their local fertilizer ordinance, how their lawn practices impact the IRL, and how to implement fertilizer and irrigation BMPs for turfgrass management. The site consultations involve a trained Master Gardener volunteer or Extension faculty visit to the participants' home to conduct an analysis of the lawn. Turf issues are addressed, problem areas are identified and solutions are offered. Fertilizer spreaders are calibrated and fertilizer recommendations are made after the soil test results are received. If the homeowner uses a landscape service, the faculty member will work with the landscaper to develop a fertilizer program that meets the fertilizer ordinance requirements and follows BMPs.
>
> Master Gardener Volunteer Program – Master Gardeners are UF-IFAS Extension trained volunteers who educate participants about Florida Friendly Landscaping™ principles.

Master Gardeners deliver educational programs, My Brevard Yard program site consultations, exhibits at events and festivals, and by speaking to community groups.

Brevard Botanical Garden –A five-acre garden is being developed on the Extension campus. The garden will be an outdoor, hands-on laboratory for educating homeowners, green industry professionals, government employees, Master Gardeners, and youth.

UF-IFAS Space Coast Golf and Turf Association Workshops – This program is targeted to golf course superintendents and turfgrass managers, especially athletic field managers. The commercial horticulture faculty member collaborates with UF scientists to provide the latest research on turf management such as weed management, fertilizer, and irrigation.

Landscape Management Program – Green industry professionals and government employees are the primary target audiences for this program. The program provides the state mandated Green Industry BMP Certification training, pesticide license exam preparation, and pesticide applicators' continuing education units. Many of the program participants are contracted with homeowner associations throughout the county, so their practices usually impact a significant amount of square footage.

Homeowner Association and Property Manager Education Program – This program began in 2016. The target audience is property managers, realtors, homeowner/condominium association boards, and developers. This program educates the participants about BMPs for lawns and ponds.

Retail Garden Center Employee Education – This program began in 2016. The target audience for this program is retail garden center employees and managers. Employees typically lack the training needed to make decisions that positively impact water quality, and they are often unfamiliar with fertilizer ordinances. Participants in this program will learn the basics of fertilizers and ordinances, and will be given resources to share with their customers that will help them make good decisions. This will be part of the upcoming fertilizer education focus, as described in the section below.

UF-IFAS also provides education to the agriculture industry including the following:

Urban and Sustainable Agricultural Production – The 2012 Agriculture Census reported more than 500 small farms in Brevard County. This program works with small farms to educate producers on water quality BMPs, technical production assistance, and pesticide management.

Livestock and Pasture Management – This program works with livestock operations on BMPs and technical expertise. Participants learn how to manage pastures and horse manure to reduce runoff pollution, as well as backyard chicken education.

UF-IFAS participates in programs through the Florida Sea Grant:

Oyster Gardening – UF-IFAS partners with Brevard County Natural Resources and the Brevard Zoo to implement the oyster gardening program (**Section 4.3.1** has more details).

Microplastic Awareness – This is a new program that raises participants' awareness of microplastic pollution in waterbodies. Citizens learn how to collect samples and filter the water to view the microplastics. The goal is help citizens make better choices when selecting health and beauty products to reduce microplastic pollution.

Florida Master Naturalist Program – This program is a collection of modules that educate participants about natural resources and the environment. After completing all of the modules, participants are awarded a certificate from UF. Once certified, participants are encouraged to become involved in the Space Coast Chapter of Florida Master Naturalist, which provides outreach and educational programs to Brevard County residents.

Ecotourism Certification (new program in 2016) – UF-IFAS partnered with the Tourism Development Office and Parks and Recreation to provide a certification program for ecotourism organizations. Through this certification, participants will learn about their impact on waterways, as well as how to educate their customers about the County's natural resources, protecting water quality, and reducing their environmental footprint.

In addition, there are several community development programs:

Sustainable Floridians℠ Program – This 10-week program teaches participants about conserving energy and water, climate change science, local food systems, recycling, and transportation issues. The IRL is a major focus of the program.

Brevard Water Summit – The summit was a collaborative effort between Brevard County Natural Resources, Marine Resources Council, and City of Melbourne. The target audience is elected officials, decision makers, and community leaders. Participants learned from local and UF experts about Brevard County-specific water issues such as water supply, water quality, agricultural water, wastewater, and low impact development.

Based on the FDACS information, the lawn fertilizer sold in Brevard County in FY2014-2015 contained 408,220 lbs of nitrogen and 32,520 lbs of phosphorus. The fertilizer applied is attenuated through several naturally occurring physical, chemical, and biological processes including uptake by grass. The environmental attenuation/uptake for urban fertilizer is 80% for nitrogen (FDEP 2014b) and 90% for phosphorus. The estimated nitrogen and phosphorus that is applied but is not naturally attenuated is shown in **Table 6**. It is important to note that not all the un-attenuated nutrients will migrate to the lagoon, either through runoff or baseflow (groundwater that enters ditches, canals, and tributaries), but these numbers provide an idea of the excess nutrients that could be reduced as a result of public education and changes in fertilizer use.

Table 6: Estimated TN and TP Not Attenuated in FY2014-2015

Parameter	Lbs Sold FY2014-15 (Lawn Only)	Environmental Attenuation (%)	FY2014-15 lbs (Lawn Only) after Attenuation
TN	408,220	80%	81,644
TP	32,520	90%	3,252

When recent sales data are compared to the fertilizer sold in FY2013-2014, which is before adoption of the more protective amendments to the ordinance, significant reductions are observed. These reductions from the implementation of the ordinance are shown in **Table 7**.

Table 7: Reductions from Fertilizer Ordinance Compliance to Date

Parameter	FY2013-14 lbs (Lawn Only) after Attenuation: Pre-Ordinance	FY2014-15 lbs (Lawn Only) after Attenuation: Post-Ordinance	Reductions from Ordinance to Date (lbs/yr)
TN	127,540	81,644	45,896
TP	12,640	3,252	9,388

Based on studies by UF, approximately 0.03% of applied nitrogen ends up in runoff during establishment of sodded bermudagrass on a 10% slope. Nitrogen leaching ranged from 8% to 12% of the amount applied (Trenholm and Sartain 2010). Therefore, nitrogen leaching from fertilizer into the groundwater is 300 to 400 times as much as the nitrogen running off in stormwater. To help address the leaching issue, the Brevard County fertilizer ordinance encourages the use of slow release nitrogen fertilizer. Slow release fertilizer decreases nitrogen leaching by about 30% (UF-IFAS 2012). In addition, the ordinance requires that fertilizer with zero phosphorus is used.

The public education and outreach campaign will be expanded to include focus on slow release and zero phosphorus fertilizers. An important component of this will be to reach out to stores within the County to ensure they are making slow release and zero phosphorus fertilizers more visible and to add signage to let buyers know which fertilizers are compliant with all local ordinances. This would cost approximately $125,000 per year for a period of five years. If an additional 25% of fertilizer users switch to 50% slow release nitrogen and zero phosphorus formulations, compliant with the ordinance, this would result in a reduction of 6,123.3 lbs/yr of TN and 813.0 lbs/yr of TP (see **Table 8**).

Table 8: Estimated TN and TP Reductions and Costs from Additional Fertilizer Ordinance Compliance

Cost	TN FY2014-15 lbs (Lawn Only) after Attenuation	TN Reductions from Additional 25% Compliance (lbs/yr)	Cost/lb/yr of TN Removed	TP FY2014-15 lbs (Lawn Only) after Attenuation	TP Reductions from Additional 25% Compliance (lbs/yr)	Cost/lb/yr of TP Removed
$625,000	81,644	6,123	$102	3,252	813	$769

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

In 2018, the Citizen Oversight Committee recommended extending the fertilizer education and outreach beyond the original plan recommendation of five years to all ten years of the plan. The $625,000 for this project will be redistributed as follows: (1) $125,000 in Year 1 to create the education campaign and begin implementation, (2) $50,000 per year to continue implementation in Years 2-10, and (3) an additional $50,000 in Year 6 (for a total of $100,000 in this year) to evaluate program success and update the outreach materials, as needed.

Grass Clippings (added in 2018)

The Brevard County fertilizer ordinance includes a paragraph concerning the management of grass clippings: "In no case shall grass clippings, vegetative material, and/or vegetative debris be washed, swept, or blown off into surface waters, stormwater drains, ditches, conveyances, watercourses, water bodies, wetlands, sidewalks or roadways. Any material that is accidentally so deposited shall be immediately removed to the maximum extent practicable" (Brevard County Section 46-343. Management of grass clippings and vegetative matter). Most municipalities have the exact or nearly similar wording for their local ordinances (Cape Canaveral, Cocoa, Cocoa Beach, Grant-Valkaria, Indian Harbour Beach, Malabar, Melbourne, Palm Bay, Palm Shores, Rockledge, Titusville, and West Melbourne). A few municipalities have altered the language slightly, including Indialantic, Melbourne Beach, and Satellite Beach.

The enforcement language for all local jurisdictions in Brevard County is identical: "Whenever in this Code any act is prohibited or is made or declared to be unlawful or an offense, or whenever the doing of any act is required or the failure to do any act is declared to be unlawful, where no specific penalty is provided therefor, the violation of any such provision of this Code shall be punished by a fine not exceeding $500.00 or imprisonment for a term not exceeding 60 days, or by both such fine and imprisonment. Each day a violation of any provision of this Code shall continue shall constitute a separate offense, and each act in violation of the provisions of this Code shall be considered a separate and distinct offense."

Current enforcement efforts are mostly reactive and educational. However, there are good examples in the state that can be followed by Brevard County to improve compliance with the grass clippings portion of the fertilizer ordinance.

The Green Industries-BMP Course is a science-based educational program developed by UF-IFAS, FDEP, and industry representatives for green industry workers. This program teaches environmentally safe landscaping practices and is required for professionals to obtain and maintain a Commercial Fertilizer Applicator license in the State of Florida. The BMPs are wide in scope and cover the importance of removing grass clippings from hard surfaces; however, management of yard waste and grass clippings is included as a small lesson in the program. The lesson includes pictures and the statement: "Clippings contain nutrients and should be recycled on the lawn. The nutrients in clippings are pollutants when they end up in stormwater systems and waterbodies (FDEP, 2010)." Another principle that is taught in the course is "Right Plant, Right Place," which recommends replacing grass with plants and mulch in areas where grass may be inappropriate. Highway medians are an example of where grass poses safety challenges associated with preventing grass clippings from being left in the pavement.

Another example is the Alachua County Public Outreach program, which includes radio spots, videos, posters, yard signs, and vehicle magnets. Alachua County has partnered with UF-IFAS staff to present their campaign during the Green Industries-BMP Course. Alachua County attempted to estimate an increase in ordinance compliance due to their campaign by through phone surveys conducted before and after the first year of the campaign. The phone surveys showed an increase in the awareness of grass clippings as pollution from 24% to 69% of respondents. The Alachua County program cost $40,000 for the initial setup with a recurring annual cost of $20,000.

Grass clippings contain nutrients and those nutrients are released in stormwater or the lagoon as they decompose (Brevard County 2017). St. Augustine grass contains 2.5% nitrogen and 0.2-0.5% (average of 0.5%) phosphorus and Bahia grass contains 2% nitrogen (UF-IFAS 2015). According to Okaloosa County Extension, a 7,500-square foot lawn produces about 3,000 pounds of clippings per year. Unfortunately, the percentage of those total clippings that end up in stormwater is not known.

To estimate the potential nutrient reduction impact of a grass clippings campaign, it was assumed that the average home size is 10,000 square feet with a 100-foot by 100-foot boundary, 2,500 square feet of built space, and 7,500 square feet of lawn. UF-IFAS has estimated that 3,000 pounds of grass clippings are produced annually from a healthy lawn of this size. It was assumed that most of the grass clippings in Brevard County are from St. Augustine grass, which means that 3,000 pounds of clippings contains approximately 75 lbs of TN and 10.5 lbs of TP. It was also assumed that the standard mower size is two feet wide. From one roadside pass along 100 feet of the average lawn with a two-foot wide mower, 200 square feet or 2.6% of the total lawn clippings could be cast into the road. This equals 0.02 lbs of TN and 0.0027 lbs of TP per foot per year left in the road. With about 3,800 miles of roads in the IRL Basin within Brevard County, of which approximately 1,250 miles are paved with curb and gutter and are most likely to allow the ready transport of grass clippings to the lagoon in stormwater, the potential nutrient release from those grass clippings could be up to 260,000 lbs/yr of TN and 35,640 lbs/yr of TP from mowing along both sides of the road. If Brevard County expects a similar rate of awareness as Alachua County (24%), then a potential 200,000 lbs/yr of TN and 27,000 lbs/yr of TP may be entering the stormwater. If a successful grass clippings campaign in Brevard County can capture an increase of awareness similar to Alachua County (from 24% to 69%), then there is a potential reduction of 88,920 lbs/yr of TN and 12,189 lbs/yr of TP. In addition, assuming the environmental attenuation/uptake for grass clippings is similar to the urban fertilizer uptake of 80% for nitrogen and 90% for phosphorus, the estimated reductions would be 17,800 lbs/yr of TN and 1,200 lbs/yr of TP.

This estimate assumes a simplified worst-case scenario in which everyone leaves a portion of their clippings in the road; however, it does not take into account the number of driveways, sidewalks, medians, and other impervious surfaces that grass clippings could be falling or the grass clippings being directly cast into the IRL, canals, and other waterways. Using the available information, this provides an order of magnitude estimate of the potential benefits of a grass clippings campaign for the IRL.

The Marine Resources Council has proposed a partnership between the IRL Basin counties to pursue a grass clippings campaign similar to the Alachua County campaign. The Citizen Oversight Committee recommended contributing $20,000 in Year 1 of the plan towards the research and marketing to develop the campaign. This will be followed by an annual investment of $20,000 per year for Years 2 through 10 for media and promotional materials targeting Brevard County. Therefore, the total project cost is $200,000. **Table 9** summarizes the costs and benefits of implementing the grass clippings campaign.

Table 9: Estimated TN and TP Reductions and Costs from Grass Clippings Campaign

Cost	Estimated TN Reductions (lbs/yr)	Cost/lb/yr of TN Removed	Estimated TP Reductions (lbs/yr)	Cost/lb/yr of TP Removed
$200,000	17,800	$11	1,200	$167

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Excess Irrigation (added in 2018)

Current scientific consensus attributes most nitrogen leaching to quick release fertilizer applied to unhealthy and poorly managed sod. Nutrients are more susceptible to leaching if turfgrass is overwatered, as these nutrients need to inhabit the upper few inches of soil to be available to the turf roots. During excess watering, soluble nutrients, such as highly mobile nitrate, wash through the soil from the root zone too quickly. Excess irrigation is easy to accomplish in Florida's sandy soils as these soils typically hold no more than 0.75 inches of water per foot of soil depth (Hochmuth et al. 2016). This excess irrigation is part of the baseflow contributing nutrient loading to the IRL.

A survey of water users in south Florida found that 85% of homeowners have their own irrigation system and 50% reported that they follow water restrictions (Odera et al. 2015). UF identifies several factors that contribute to improper residential irrigation:

- Lack of understanding about urban soils.
- No familiarity with the different water requirements of landscape plants, including the water required during plant establishment and the water needs based on species, season, soil type, shade in the landscape, etc.
- Lack of attention to proper design, maintenance, and management of the irrigation system.

For St. Augustine turfgrass in Brevard County, UF-IFAS recommends 2 – 5 lbs of nitrogen/1,000 ft^2/year. FDACS rules allow for 2 lbs of nitrogen/1,000 ft^2 per application in summer and spring and 1 lb of nitrogen/1,000 ft^2, with no more than 0.7 lbs of nitrogen/1,000 ft^2 of quick release soluble nitrogen per application. Local city and county ordinances along the IRL ban the application of nitrogen during the wet season (June – September) to reduce the risk that fertilizer will be washed off or leached through turf by frequent heavy rainfall events.

Established St. Augustine turfgrass maintained at UF recommendations has typical nitrogen leaching of 1%. Other grass species and landscaping types can have far higher rates of leaching. A few studies have measured increased leaching with excessive irrigation. Overwatered bermudagrass resulted in an 8-12% nitrogen loss through leaching (Trenholm & Sartain, 2010). A study in sandy loam soil of Rhode Island measured a five-fold increase in soluble nitrogen leaching due to overwatering. In that study, the overwatered turf leached 13% of applied nitrogen, whereas the turf watered on an as-needed basis leached 2% of applied nitrogen (Morton et. al. 1988).

From June 2015 to May 2016, 470,737 lbs of TN in fertilizer were sold within Brevard County. FDACS Urban Turf Fertilizer Rule (RE-1.003[2], Florida Administrative Code) does not specify a percentage of slow-released nitrogen in fertilizer or separately track slow-release nitrogen from all nitrogen sources. However, if it is assumed that 50% of fertilizer was soluble nitrogen (compliant with local fertilizer ordinances), then the total soluble nitrogen sold in Brevard County could be as high as 235,368 lbs/yr. If 13% of soluble nitrogen were leached, up to 30,597 lbs/yr of TN could potentially be entering the groundwater. If like South Florida survey respondents 50% of irrigation users in Brevard County are not over-irrigating, and if an outreach campaign can impact half of those who do over-irrigate, fertilizer leaching could be reduced by 7,649 lbs/yr of TN. As noted above, the environmental attenuation/uptake for urban fertilizer is 80% for nitrogen (FDEP 2014b). Therefore, the total amount of TN that could be reduced by reducing excess irrigation is 1,530 lbs/yr.

Conducting an outreach campaign with an initial $50,000 social marketing research and development investment and $25,000 in annual implementation, the total 10-year budget would be $300,000. This results in an average of $196/lb of TN reduced per year (see **Table 10**).

Table 10: Estimated TN Reductions and Costs from Reducing Excess Irrigation

Cost	Estimated TN Reductions (lbs/yr)	Cost/lb/yr of TN Removed
$300,000	1,530	$196

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Stormwater Pond Maintenance (added in 2018)

Wet detention ponds, or stormwater ponds, are one method used to remove nutrients from stormwater as part of stormwater management mandated by Florida Statute 403.0891. These areas often have one or more stormwater pipes that drain into the pond with a smaller diameter outflow to increase retention/detention time of water in the pond. The retention time increases removal of accumulated nutrients by allowing material to settle and be absorbed. By itself, an optimally sized and properly maintained stormwater pond typically has a 35-40% removal of nitrogen through settling (FDEP and WMDs 2010). Additional behaviors and technologies can be combined with ponds to increase removal rates.

UF-IFAS Extension researchers conducted focus groups assessments and found that 48% of respondents “don’t know where runoff goes” or “don’t know what runoff is” (Seevers, Graham, Gamon, and Conklin, 1997). Pollution prevention programs promoting BMPs are more cost effective than restoration or stormwater treatment but require residents to make changes in their lifestyles to reduce their personal contribution to nutrient impacts. Education regarding stormwater BMPs has been shown to increase adoption of BMPs and improve water quality (Brehm, Pasko, and Eisenhauer 2013; Deitz, Clasen, and Filchak 2004; Swann 2000). UF-IFAS outlined many BMPs related to stormwater in their Florida Friendly Landscaping Program™. Examples of recommended BMPs include (Ott, Monaghan, Wells, et. al. 2015):

- Creating a low-maintenance buffer of at least 10 feet along water features that requires no mowing, fertilizer, or pesticide.
- Following UF-IFAS recommendations for fertilizer rate, application, and timing.
- Avoiding the application of fertilizer on hard surfaces like curbs, sidewalks, and roads.
- Cleaning up any spilled fertilizer.
- Avoiding fertilizer application before heavy rainfall.
- Keeping grass clippings on lawns and off streets and sidewalks (where they wash into drains and enter ponds).
- Picking up pet waste to prevent harmful bacteria and organisms from entering waterways.
- Adjusting fertilizer amount to account for the nutrients in reclaimed water.

Many of these stormwater BMPs are promoted by existing programs like Blue Life™ or will be covered by other individual education and outreach included in this plan. Therefore, the stormwater pond maintenance program will focus on vegetative buffers and their appropriate maintenance to reduce stormwater pollution. Brevard County contains 4,175 stormwater ponds covering 13,276 acres with 6,976,338 linear feet of shoreline. The average size of a pond is 3.2 acres with 1,671 linear feet of shoreline. These numbers include ponds affiliated with both residential and commercial areas. The average load to stormwater ponds is 11.4 lbs of TN per acre of land surrounding the pond annually according to FDEP’s Spreadsheet Tool for Estimating Pollutant Loads (STEPL). Assuming that a 50-foot perimeter directly impacts the pond, there are 8,008 acres contributing 91,288 lbs of TN annually to the ponds. Of this, up to 40% of the TN is removed through retention in the pond leaving a potential 54,773 lbs/yr of TN to enter the lagoon. For TP, approximately 18,836 lbs/yr is entering the stormwater pond. Of this, up to 65% of the TP is removed through retention in the pond leaving a potential of 6,593 lbs/yr TP to enter the lagoon.

Creating a 10-foot-wide low-maintenance buffer zone of grasses has the potential to remove about 25% of the TN and TP entering the pond (USEPA 2005). This amount increases with the width of the buffer and the addition of woody vegetation. For the plan calculations, the assumption was made that convincing homeowners to not mow a 10-foot buffer is the easiest practice to achieve. The pond will remove up to 40% of the remaining TN. Assuming that the education campaign can reach at least half of the 48% of people unaware of what stormwater is, the reduction could be 3,286 lbs/yr of TN and 396 lbs/yr of TP.

Conducting an outreach campaign with an initial $50,000 social marketing research and development investment plus $25,000 in annual implementation, would require a 10-year total budget of $300,000. This would result in reductions at $91/lbs of TN and $750 lbs/yr of TP (see

Table 11). Additionally, during focus group research in the first year, it may be possible to identify other BMPs that homeowners' associations are willing to adopt that would further improve the performance of their stormwater pond. This would improve the cost effectiveness of this campaign.

Table 11: Estimated TN and TP Reductions and Costs from Stormwater BMP Maintenance

Cost	Estimated TN Reductions (lbs/yr)	Cost/lb/yr of TN Removed	Estimated TP Reductions (lbs/yr)	Cost/lb/yr of TP Removed
$300,000	3,300	$91	400	$750

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Septic Systems Maintenance (added in 2018)

Nationwide, 10-20% of septic systems are failing from overuse, improper maintenance, unsuitable drainfield conditions, and high-water table. When septic systems are older and failing or are installed over poor soils close to the groundwater table or open water, they can be a major contributor of nutrients and bacterial and viral pathogens to the system.

Overuse can occur when too much water is flushed through the system, which does not allow the microbes to properly process the nutrients. Overuse can also occur when more solids enter the tank than can be decomposed by the microbes. With improper and infrequent maintenance, sludge can build up in the tank which decreases its capacity. In addition, cracks and damage to the tank may go undiagnosed, which allows for prolonged leakage of untreated effluent into the groundwater. Improper maintenance can also allow solids to clog the drainfield, which inhibits its ability to process nutrients and pathogens. Nutrient and pathogen processing also declines when drainfields are flooded by a high-water table.

A properly functioning septic tank and drainfield system reduces TN by 30-40%. However, the reduction has been measured at 0-20% in adverse conditions. The best available studies estimate a 10% reduction in nitrogen within a properly maintained tank versus an improperly maintained tank. The remaining 20-30% of nitrogen removal occurs in a properly functioning drainfield. If 10% of systems are failing and failing systems attenuate 30% less of the nitrogen load, these systems may pose far greater impacts to the groundwater, tributaries, and lagoon than the average impact reported for properly functioning systems. Without the 30% reduction, the potential load to the IRL and its tributaries is estimated to be 39 lbs/yr of TN for properties within 50 meters (instead of 27.1 lbs/yr of TN for functioning systems) and 10 lbs/yr of TN for properties up to 200 meters away (instead of 6.9 lbs TN/yr for functioning systems).

There are an estimated 59,438 septic systems in Brevard County within the IRL Basin. Of these, 41,077 are close enough to the IRL and its tributaries to be contributing significant amounts of nitrogen. To address this source, this plan is funding either removal or upgrades of the 3,734 septic systems responsible for the highest likely pollutant loads. The remaining 37,343 systems are still impacting the IRL based on their location, and many of these may be failing based on USEPA reports of failure rates.

As noted in **Section 4.1.4**, the total loading of septic systems within 50 meters of the IRL and its tributaries is calculated at 408,863 lbs/yr of TN, and the total loading of systems within 200 meters is 178,395 lbs/yr of TN. If the failure rate in Brevard County is about 10%, and if failing systems receive 30% less attenuation, then failing systems within 50 meters of open water are contributing an extra 17,957 lbs/yr of TN while failing systems between 50 and 200 meters of open water are contributing an extra 8,145 lbs/yr of TN. By factoring in this failure rate, the total additional loading to the IRL from failing septic systems is approximately 26,102 lbs/yr of TN.

A 10-year outreach campaign budget of $300,000, which includes $50,000 for research and campaign development and $25,000 per year for implementation, would strive to reduce the number of failing systems county-wide by 25%, thereby reducing the excess loading from failing systems by 6,525 lbs/yr of TN. This would result in average cost of $46/lb of TN (see **Table 12**).

Table 12: Estimated TN Reductions and Costs from Septic System Maintenance

Cost	Estimated TN Reductions (lbs/yr)	Cost/lb/yr of TN Removed
$300,000	6,500	$46

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

4.1.2 WWTF Upgrades

Upgrades for Reclaimed Water

88% of the reclaimed water in the County is used in public access areas and for landscape irrigation.

The direct WWTF discharges to the lagoon have been largely removed, and the majority of facilities in the basin use the treated effluent for reclaimed water irrigation. While the use of reclaimed water for irrigation is an excellent approach to conserving potable water, if the reclaimed water is high in nutrient concentrations, the application of the reclaimed water for irrigation can result in nutrients leaching into the groundwater. It is important to note that there are no regulations on the concentration of nutrients in reclaimed water that is used for irrigation. However, UF-IFAS studies indicate that a nitrogen concentration of 5 to 9 mg/L is optimal for turfgrass growth, and each year a maximum amount of 1 lb of nitrogen can be applied per 1,000 ft^2 of turf (UF-IFAS 2013a and 2013b). Nitrogen leaching increases significantly when irrigation is greater than 2 cm/week (0.75 in/week), even if the nitrogen concentrations are half of the maximum IFAS recommendation of 9 mg/L.

In Brevard County, 88% of the reclaimed water is used in public access areas and for landscape irrigation. The total reclaimed water used countywide is approximately 18.5 million gallons per day (mgd), which is applied over 7,340 acres. The unincorporated County and city WWTFs with the reclaimed water flows and TN concentrations are shown in **Table 13**. This table also summarizes the excess TN in the reclaimed water after environmental attenuation/uptake (75% for TN [FDEP 2017]), for both the current TN effluent concentration and if the facility were upgraded to achieve a TN effluent concentration of 6 mg/L (the City of Palm Bay WRF update would achieve a TN effluent concentration of 7.5 mg/L and the City of Melbourne Grant Street WWTF would achieve a TN effluent concentration of 5 mg/L).

Table 13: TN Concentrations in WWTF Reclaimed Water

Facility	Permitted Capacity (mgd)	Reclaimed Water Flow (mgd)	TN Concentration (mg/L)	TN After Attenuation (lbs/year)	TN After Attenuation and Upgrade (lbs/year)
City of Palm Bay Water Reclamation Facility (WRF)	4.0	0.656	29.4	14,927	3,808
City of Melbourne Grant Street WWTF	5.5	2.08	21.0	33,806	8,049
City of Titusville Osprey WWTF	2.75	1.56	17.9	21,612	7,244
Brevard County Barefoot Bay Water Reclamation Facility	0.9	0.48	11.9	4,421	2,229
Brevard County North Regional WWTF	0.9	0.26	11.4	2,294	1,207
City of West Melbourne Ray Bullard WRF	2.5	0.85	11.1	11,684	6,315
Brevard County Port St. John WWTF	0.5	0.35	10.7	2,898	1,625
Brevard County South Beaches WWTF	8.0	1.12	9.3	8,061	5,201
Rockledge WWTF	4.5	1.40	7.0	12,136	10,402
Brevard County South Central Regional WWTF	5.5	3.79	6.7	19,653	17,600
City of Titusville Blue Heron WWTF	4.0	0.84	4.8	4,993	N/A
City of Cape Canaveral WRF	1.8	0.88	3.8	4,141	N/A
City of Cocoa Jerry Sellers WRF	4.5	1.44	3.5	6,241	N/A
Brevard County Sykes Creek WWTF	6.0	1.48	3.4	3,895	N/A
City of Cocoa Beach WRF	6.0	3.66	2.5	11,331	N/A

The estimated costs for the WWTF upgrade and the cost per pound of nitrogen removed as a result of the upgrade are shown in **Table 14**. Based on a 2007 study by U.S. Environmental Protection Agency (USEPA), the cost to upgrade WWTFs to meet advanced wastewater treatment standards is approximately $4,200,000 per plant. This cost is in 2006 dollars, which, when inflated to 2016 dollars and costs are included for design and permitting, is approximately $6,000,000 per facility. Where cost estimates were available for facility upgrades, these costs were used instead of the USEPA inflated estimated. Due to the high cost per pound of TN removed to upgrade some of these facilities compared to other projects in this plan, only those facilities highlighted in green are recommended for upgrades as part of this plan.

Table 14: Cost per Pound of TN Removed from WWTF Upgrades to Improve Reclaimed Water

Facility	Cost to Upgrade	TN Removed after Attenuation (lbs/yr)	Cost/lb/yr of TN Removed
City of Palm Bay WRF	$1,400,000	11,119	$125
City of Titusville Osprey WWTF	$8,000,000	14,368	$557
City of West Melbourne Ray Bullard WRF	$6,000,000	5,368	$1,118
Barefoot Bay WRF	$6,000,000	2,192	$2,737
Port St. John WWTF	$6,000,000	1,273	$4,713
City of Melbourne Grant Street WWTF*	$6,000,000	1,107*	$5,421*
North Regional WWTF	$6,000,000	1,087	$5,522

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.
* After the plan was adopted, it was determined that the reclaimed water flow and TN concentration used for the Melbourne Grant Street WWTF were incorrect. The actual TN that could be removed from this project is 25,627 lbs/yr. This project was added to the plan as part of the 2018 Update (see **Section 6.3**).

As part of the public education and outreach efforts, customers who use reclaimed water for irrigation should be informed of the nutrient content in the reuse water because they can and should eliminate or reduce the amount of fertilizer added to their lawn and landscaping. This information can be provided to the customers through their utility bill.

4.1.3 Sewer Laterals Rehabilitation (added in 2018)

Sewage overflows following heavy rainfall events are an indicator of illegal connections or inadequate sewer asset conditions. There are three major components of wastewater flow in a sanitary sewer system: (1) base sanitary (or wastewater) flow, (2) groundwater infiltration, and (3) rainfall inflow. Virtually every sewer system has some infiltration and/or inflow (I&I). Historically, small amounts of I&I are expected and tolerated. However, I&I becomes excessive when it causes overflows, health, and/or environmental risks. Overflows from the South Beaches WWTF sewer system have occurred 7 of the last 13 years, including significant overflows following Hurricane Matthew in 2016 and Hurricane Irma in 2017. Less frequent overflows and line breaks have occurred in other sewer service areas.

In 2012, in recognition of aging infrastructure and increasingly frequent issues, the Brevard County Utilities Services Department engaged seven professional engineering firms to perform independent field evaluations of the condition of the sewage infrastructure assets located in each of the County's seven independent sewer service areas. The output of this investigation was identification of $134 million in specific capital improvement needs required over a ten-year period to bring County-owned sewer system assets up to a fully-functional, reliable, affordable, efficient, and maintainable condition (Brevard County Utilities Services 2013). The field evaluation results and corresponding 10-year Capital Improvement Program Plan were presented to the Brevard County Commission in 2013. In response, the Commission approved financing the entire Capital Improvement Program Plan and increased the County's sewer service rates to repay the debt. Plan implementation began in 2014 and projects are progressing quickly.

Because there was already a capital improvement plan and funding mechanism for updating the County's aging sewer system infrastructure, the original Save Our Indian River Lagoon Project Plan did not include analysis or funding for sewer system repairs. Unfortunately, even in areas where capital improvements have been made, I&I continues to be a problem that contributes to overflows that discharge untreated wastewater into the IRL. This indicates the probability of problems outside the County-owned assets and could include illegal connections and/or leaks in the privately owned lateral connections of homes and businesses to the County sewer system.

Identifying problems on the customer side of the connection will require smoke testing each building or private residence to determine if leaks or illegal connections are present. The extent of I&I on the customer side of the connections is unknown and, therefore, the nutrient loading associated with these issues are also unknown. As a first step to determine the extent of I&I problems with the sewer laterals, the County is partnering with the City of Satellite Beach on a pilot project to perform smoke testing of approximately 5,400 buildings and residences within the city in March through May of 2018. Based on the data collected during the pilot study, an evaluation will be made on the next steps to reduce nutrient loading from broken or leaky sewer laterals.

Repair of privately owned portions of the sewer system is not funded in the adopted Capital Improvement Program Plan; therefore, consideration has been given to the use of the Save Our Indian River Lagoon Tax funding. The Brevard County Utilities Services Department estimates that I&I due to rainfall and flooding associated with Hurricane Irma, caused 1,835 lbs/yr of TN and 350 lbs/yr of TP to enter the lagoon from sewer overflowing from the South Beaches Regional WWTF sewer system. If repairing private connections could prevent similar overflows in the next 7 out of the last 13 years, then the average annual nitrogen reduction benefit of such repairs would be approximately 988 lbs/yr of TN. The average cost effectiveness of sewer expansion projects funded in the 2017 Plan Supplement was $852 per pound of nitrogen removed, thus the cost to reduce 988 lbs/yr of TN loading by implementing septic to sewer projects would be $841,842. Therefore, this 2018 plan update includes a reserve of $840,000 to assist property owners with the cost to repair leaky sewer connections expected to be found through smoke testing.

The Save Our Indian River Lagoon Trust Fund will also be used to conduct performance monitoring to measure the nutrient reduction benefits of repairing privately-owned leaky lateral connections. The results of performance monitoring will be used to consider expansion of this program from the Satellite Beach pilot areas to other city and county sewer service areas.

Table 15: Estimated Sewer Laterals Rehabilitation TN and TP Reductions and Costs

Project	Number of Buildings	Cost	Estimated TN Reductions (lbs/yr)	Cost/lb/yr of TN Removed	Estimated TP Reductions (lbs/yr)	Cost/lb/yr of TP Removed
Satellite Beach Pilot Area	5,400	$840,000	988	$850	188	$4,468

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

4.1.4 Septic System Removal and Upgrades

One septic system within 55 yards of a surface waterbody contributes 27 lbs of TN per year.

Septic systems are commonly used where central sewer does not exist. When properly sited, designed, constructed, maintained, and operated, septic systems are often a safe means of disposing of domestic waste but still add nutrients to the system. However, when septic systems are older and failing or are installed over poor soils close to the groundwater table or open water, they can be a major contributor of nutrients and bacterial and viral pathogens to the system. There are an estimated 59,438 septic systems in Brevard County within the IRL Basin (**Table 16**). In order to address this source, options for both septic system removal and septic system upgrades were evaluated. It is important to note that although the County is taking the lead on these projects, the Florida Department of

Health (FDOH) is responsible for the regulation and permitting of septic systems. The County will coordinate with FDOH on the septic system projects recommended in this plan.

Table 16: Location of Septic Systems in Brevard County

Area	Number of Septic Systems
St. Johns River Basin	22,514
Banana River Lagoon	4,628
North IRL	15,899
Central IRL	38,911
Total	***81,952***

Septic System Removal

To identify potential locations for septic system removal through connection to the central sewer system, the County prioritized those areas with septic systems in close proximity to surface waters (ditches, canals, creeks, and the IRL). As shown below in **Table 19**, septic systems within 55 yards of a surface water have the greatest impact and systems more than 219 yards from a surface water contribute very little TN loading. In addition, the County also inventoried existing sewer service areas for available capacity. The existing service areas include:

- Brevard County North Brevard (Mims)
- Brevard County Port St. John
- Brevard County Sykes Creek (Merritt Island)
- Brevard County South Central (Suntree and Viera)
- Brevard County South Beaches (Patrick AFB to Melbourne Beach)
- Brevard County Barefoot Bay
- City of Cape Canaveral
- City of Cocoa
- City of Cocoa Beach
- City of Melbourne
- City of Palm Bay
- City of Rockledge
- City of Titusville
- City of West Melbourne

The estimated cost per lot for connection to central sewer lines is $20,000 and includes electrical work, plumbing, removing the septic tank, and sewer connection fees. The actual cost per lot will vary depending on site conditions. This amount of funding would offset most, if not the entire, cost per customer.

The estimated nutrient loads from the septic systems that will travel through the groundwater and intersect with a surface waterbody (tributaries, canals, and the lagoon itself) were estimated using typical septic system effluent concentrations and decay rates from USEPA (2002) (**Table 17**). This information is for a single family residential property. For projects with septic systems for other buildings (apartments, commercial, etc.), loading estimates can be scaled by comparing the flow data for that property to the average flow volume for single family residential. The estimated travel times based on the distance from the septic system to a waterbody are shown in **Table 18**, and is based on an interpretation of the results from a recent study in the City of Port St. Lucie by Sayemuzzaman and Ye 2015. The concentration of each parameter for each buffer zone was calculated using the effluent concentration and decay rates in **Table 17** and the travel times in **Table 18**. The concentrations used in the estimates for this plan are shown in **Table 19**.

Table 17: Septic System Effluent Concentrations and Decay Rates

Parameter	Effluent Concentration (mg/L)	Decay Rate (1/day)
TN	70	0.1
Organic N	0.458	0.1
Ammonia	10.5	0.1
Nitrate + Nitrite	59.3	0.0011
Organic P*	0.3	0.014
Orthophosphate*	0	0.014

* Assumes that 90% of phosphorus is sorbed to sediment.

Table 18: Travel Time Based on Distance from Septic System to Waterbody

Buffer Zone	Travel Distance (yards)	Average Velocity (yards/day)	Average Travel Time (days)	Average Travel Time (years)
1	<55	0.199	137.6	0.4
2	55-219	0.138	1,385.7	3.8
3	>219	0.066	9,641.0	26.4

Table 19: Parameter Concentrations from Each Buffer Zone

Parameter	Buffer Zone 1 Concentration (mg/L)	Buffer Zone 2 Concentration (mg/L)	Buffer Zone 3 Concentration (mg/L)
Organic N	0.000	0.000	0.000
Ammonia	0.000	0.000	0.000
Nitrate + Nitrite	50.971	12.914	0.001
Organic P	0.044	0.000	0.000
Orthophosphate	0.000	0.000	0.000

The cost for connection of all the septic systems in the County within the IRL watershed would be approximately $1.2 billion (see **Table 20**). Therefore, this plan focuses on the locations where reductions through septic system removal are the most cost-effective.

Table 20: Cost to Remove Septic Systems Based on Distance from a Surface Waterbody

Septic System Distance from Surface Water	Number of Septic Systems	TN (lbs/yr/system)	TN (lbs/yr)	Cost/System to Connect	Total Cost	Cost/lb/yr of TN
Less than 55 yards	15,090	27.095	408,863	$20,000	$301,800,000	$738
Between 55 and 219 yards	25,987	6.865	178,395	$20,000	$519,740,000	$2,913
Greater than 219 yards	18,361	0.001	10	$20,000	$367,220,000	$37,624,010
Total in IRL Basin	***59,438***	***N/A***	***587,268***	***$20,000***	***$1,188,760,000***	***$2,024 (average)***

Short-term and long-term opportunities for septic system removal were then identified. Short-term opportunities are neighborhoods with more than 50% of the septic systems being less than 55 yards from a surface water directly connected to the lagoon, and that only require limited extensions of infrastructure from existing service areas to connect to sewer service. In addition, short-term opportunities included areas where there are existing sewer lines and the buildings on septic systems only needed to be connected to the sewer system. The County identified these locations using data from FDOH, which were updated using the most current information from the cities. The FDOH data likely still require updates and corrections; therefore, this plan provides the flexibility for projects to address field verified septic systems that are having the greatest impact on the lagoon (within 55 yards of a surface waterbody).

For the short-term opportunities, the number of lots that could be connected, associated cost of the connection, and estimated TN reductions are shown in **Table 21** for the Banana River Lagoon, **Table 22** for the North IRL, and **Table 23** for the Central IRL. **Appendix C** includes maps of each of these areas. Based on the cost per pound of TN removed, it was determined that the most cost-effective sewer connection projects were those that cost less than $1,200 per pound. The areas that could be connected for this cost are highlighted in green, and these highlighted areas are recommended for connection as part of the plan. These short-term opportunities represent the connection of approximately 3.9% of the septic systems in Brevard County within the IRL Basin. In Palm Bay, an opportunity exists to hook up many lots to existing sewer lines for $12,000 per connection. This is recommended for high priority septic systems located within 55 yards of an open water connection to the lagoon.

Table 21: Short-Term Opportunities for Septic System Removal in Banana River Lagoon

Service Area	Number of Lots	Cost	TN Reduction (lbs/yr)	TN Cost/lb/yr
Sykes Creek - Zone N	86	$1,720,000	2,330	$738
Sykes Creek - Zone M	58	$1,160,000	1,572	$738
Sykes Creek - Zone T	139	$2,780,000	3,685	$754
Sykes Creek - Zone X	14	$280,000	359	$780
Sykes Creek - Zone V	98	$1,960,000	1,927	$1,017
Sykes Creek - Zone U	145	$2,900,000	2,573	$1,127
Sykes Creek - Zone Z	73	$1,460,000	1,290	$1,132
Sykes Creek - Zone W	142	$2,840,000	1,923	$1,477
Sykes Creek - Zone R	206	$4,120,000	2,686	$1,534
Sykes Creek - Zone Q	186	$3,720,000	2,319	$1,604
Sykes Creek - Zone S	163	$3,260,000	1,407	$2,317

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 22: Short-Term Opportunities for Septic System Removal in North IRL

Service Area	Number of Lots	Cost	TN Reduction (lbs/yr)	TN Cost/lb/yr
City of Cocoa – Zone K	34	$680,000	921	$738
City of Melbourne	12	$240,000	325	$738
City of Rockledge	16	$320,000	434	$738
South Beaches - Zone A	42	$840,000	1,098	$765
City of Titusville	33	$660,000	833	$792
City of Cocoa – Zone J	78	$1,560,000	1,891	$825
South Central - Zone C	132	$2,640,000	3,132	$843
South Central - Zone A	115	$2,300,000	2,239	$1,027
South Central - Zone D	94	$1,880,000	1,730	$1,087
Sykes Creek - Zone C	85	$1,700,000	1,426	$1,192
Sykes Creek - Zone B	207	$4,140,000	3,038	$1,363
Port St. John - Zone B	197	$3,940,000	2,849	$1,383
South Central - Zone B	190	$3,800,000	2,486	$1,528
Sykes Creek - Zone H	77	$1,540,000	992	$1,552
Sykes Creek - Zone I	31	$620,000	386	$1,605
Sykes Creek - Zone G	53	$1,060,000	632	$1,679
Sykes Creek - Zone J	55	$1,100,000	503	$2,186
Sykes Creek - Zone K	170	$3,400,000	1,539	$2,210
Sykes Creek - Zone O	161	$3,220,000	1,158	$2,782
Sykes Creek - Zone A	247	$4,940,000	1,767	$2,796
Sykes Creek - Zone Y	168	$3,360,000	1,083	$3,102
Sykes Creek - Zone F	24	$480,000	95	$5,051
Sykes Creek - Zone L	175	$3,500,000	687	$5,098
Sykes Creek - Zone P	342	$6,840,000	1,074	$6,372
Sykes Creek - Zone E	86	$1,720,000	217	$7,934
Sykes Creek - Zone D	85	$1,700,000	183	$9,279
Port St. John - Zone C	82	$1,640,000	96	$17,058
South Beaches - Zone B	170	$3,400,000	123	$27,742
Port St. John - Zone A	55	$1,100,000	7	$159,571

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 23: Short-Term Opportunities for Septic System Removal in Central IRL

Service Area	Number of Lots	Cost	TN Reduction (lbs/yr)	TN Cost/lb/yr
City of Palm Bay – near sewer lines	647	$7,764,000	17,530	$443
City of Palm Bay – Zone B	235	$4,700,000	6,347	$741
City of West Melbourne	112	$2,240,000	2,974	$753
City of Palm Bay – Zone A	99	$1,980,000	1,893	$1,046
South Beaches - Zone D	62	$1,240,000	558	$2,221
South Beaches - Zone C	124	$2,480,000	579	$4,282

Table 24: Summary of Septic System Removal Projects by Sub-Lagoon

Sub-lagoon	Number of Lots	Cost	TN Reductions (lbs/yr)	Average Cost/lb/yr of TN
Banana River Lagoon	613	$12,260,000	13,736	$898
North IRL	641	$12,820,000	14,029	$875
Central IRL	446	$8,920,000	11,214	$795
Total	***1,700***	***$34,000,000***	***38,979***	***$872***

Note: This summary does not include the connection of septic systems near existing sewer lines in Palm Bay.

There are also areas identified for long-term septic system connection opportunities, which are listed in **Table 25**. The long-term opportunities require more time and expense to build WWTF capacity and service infrastructure. Therefore, these systems are not recommended for funding as part of this plan. However, these areas have a large concentration of septic systems that are impacting the lagoon, and other funding options to address the septic systems in these areas could be explored in the future, if needed.

Table 25: Long-Term Opportunities for Septic System Connections

Service Area	Number of Lots	Cost	TN Reduction (lbs/yr)	TN Cost/lb/yr
South Merritt Island	1,903	$38,060,000	25,086	$1,517
North Merritt Island	1,487	$29,740,000	19,148	$1,553
Port St. John	688	$13,760,000	6,806	$2,022
South Beaches	2,347	$46,940,000	22,095	$2,125
Little Hollywood	802	$16,040,000	7,123	$2,252
Port St. John – Cocoa Gap	974	$19,480,000	7,618	$2,557
Total	***8,201***	***$164,020,000***	***87,876***	***$2,004 (average)***

Another opportunity for removing septic systems is to use a hybrid septic tank effluent pumping (STEP) system. In this system, effluent from the septic tank is connected to sewer pressure lines. Small-diameter pipes, which can be installed relatively quickly, are used instead of the gravity sewer system. A high pressure ½ horse power pump (115 volt) pumps the effluent from the septic system to a force main or gravity sewer system. The City of Vero Beach is installing these systems and they are leaving the drainfields in place, which saves money and allows for a backup in the event that a power outage affects the STEP pumping system. If the drainfield is not left in place, a 500-gallon pump chamber is installed to allow enough reserve capacity to address power outages. Each STEP system also has an emergency generator receptacle to address long-term power outages associated with hurricanes. The estimated cost per connection is $6,000 to $10,000, which includes the cost of the pipes. The City of Vero Beach maintains the STEP system and pumps out the septic tank when needed. The customer pays the electrical costs to operate the pump for this system.

For properties within 55 yards of a waterbody and located within the vicinity of a pressure line or gravity sewer system, the STEP system may be a good option instead of the septic system upgrades described below. If STEP systems are selected as a preferred option anywhere in Brevard County, specific locations for STEP system installation can be submitted for funding consideration through the annual project funding request and plan update process.

Septic System Upgrades

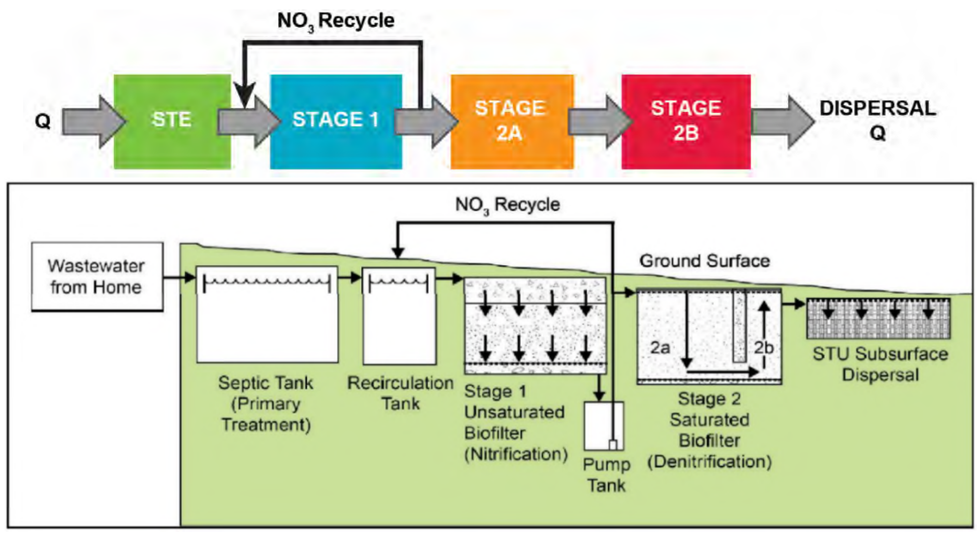
In locations where providing sewer service is not feasible due to distance from sewer infrastructure, facility capacity, or insufficient density of high risk systems, there are options to upgrade the highest risk septic systems to increase the nutrient and pathogen removal efficiency. In recent years, research has been conducted on passive treatment systems, which provide significant treatment efficiencies without monthly sewer fees or highly complex maintenance needs for mechanical features.

One option for a septic system upgrade is to add a biosorption activated media (BAM) to enhance nutrient and bacterial removal before the effluent reaches the drainfield or groundwater. Examples of BAM include mixes of soil, sawdust, zeolites, tire crumb, vegetation, sulfur, and spodosols (Wanielista et. al. 2011). A test of the BAM removal capacity was conducted at Florida's Showcase Green Envirohome in Indialantic, Florida. This test location is a residential site built with stormwater, graywater, and wastewater treatment in a compact footprint onsite (Wanielista et. al. 2011). The media used in this study was Bold & Gold™, which is a patented blend of mineral materials, sand, and clay. In this study, the effluent to the septic tank was evenly divided between a sorption filter media bed/conventional drainfield in series (innovative system) and to a conventional drainfield. The study found that the TN and TP removal efficiencies were 76.9% and 73.6%, respectively, for the Bold & Gold plus drainfield system, which was significantly higher than the 45.5% TN removal and 32.1% TP removal from a conventional drainfield alone.

Another pilot study was conducted at the University of Central Florida using wastewater from the 15-person BPW Scholarship House, which contains a kitchen and living quarters. The wastewater is pumped to septic tanks from where the effluents are divided into the test Bold & Gold drainfield and the standard drainfields. The Bold & Gold system was designed to provide aerobic and anoxic environments, which allowed for nitrification and denitrification to occur. In this study, the media used was a sand layer on top of a mixture of approximately 68% fine sand, 25% tire crumbs, and 7% sawdust by volume. Overall, TN was reduced by 70.2% and TP was reduced by 81.8%. In addition, the removal efficiency of *Escherichia coli* was 99.93% (Chang et. al. 2010).

Another option for a septic system upgrade is the use of passive nitrogen removing systems, and FDOH recently completed a study on the efficiency and costs of these systems. FDOH defines a passive system as, "A type of enhanced conventional onsite sewage treatment and disposal system that excludes the use of aerator pumps, includes no more than one effluent dosing pump with mechanical and moving parts, and uses a reactive media to assist in nitrogen removal." This definition of passive includes the use of up to one pump because of Florida's flat topography and the need to move water to allow for treatment (FDOH 2015).

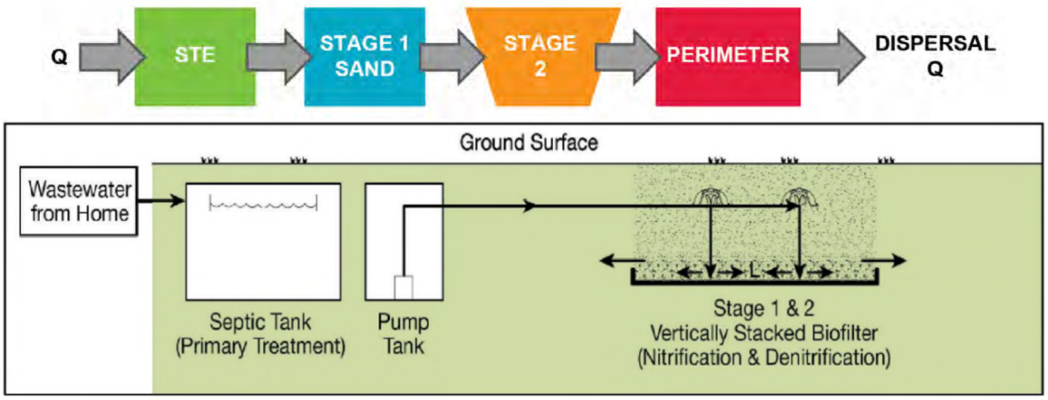
To determine the feasibility of using passive nitrogen removing system, FDOH contracted with Hazen and Sawyer. The types of passive systems that were tested fell into two general categories: (a) in-tank system and (b) in-ground system. In the in-tank system concept, wastewater flows through the septic tank (STE) to a tank filled with an unsaturated layer of expanded clay (lignocellulosic material) (Stage 1). The wastewater is then sent to a pump tank (NO_3 Recycle), which recycles a portion back to the top of Stage 1. The rest of the wastewater is pumped into a tank with two sections: a saturated layer of wood-chip material (Stage 2A), and a saturated mixture of sulfur and oyster shells (Stage 2B). The wastewater then flows by gravity to the existing drainfield or soil treatment unit (STU) (Dispersal). This concept is shown in **Figure 10.**



Note: from Hazen and Sawyer 2015

Figure 10: Example Diagram of an In-Tank Two Stage Biofilter

In the in-ground system concept, wastewater flows through the septic tank (STE) to a pump tank which pressure doses a lined drainfield to spread the sewage throughout the drainfield. Under the drainfield, within the liner, are two layers: an unsaturated layer of regular drainfield sand (Stage 1) above a saturated layer of wood-chip material (Stage 2). The treated wastewater flows over the rim of the liner (Perimeter) into the soil (Dispersal). This concept is shown in **Figure 11**.



Note: from Hazen and Sawyer 2015

Figure 11: Example Diagram of an In-Ground Stacked Biofilter

In the test systems, the media depth ranged from 10 inches to 30 inches. The tanks used in the systems at the test sites ranged from 1,050 gallons to 2,800 gallons (Hazen and Sawyer 2015). System longevity could not be directly determined in these systems due to the very low use of media over the two-year study period. Theoretical calculations and literature review suggest that these systems could have a media life of 25 years or longer. For the in-tank Stage 2 biofilters, it would be relatively easy to replace reactive media, helping to extend the life of the system. The study systems were all retrofits of existing septic systems, which have a higher cost than new construction. In addition, these were prototype systems that were being constructed for the first time in Florida. The costs of these systems are expected to decrease with more widespread implementation. The estimated cost to retrofit a septic system to an in-tank passive system is $15,500 and the cost to retrofit to an in-ground system is $12,000. The results of the study found that the TN removal efficiency ranged from 65% to 98%, with an average removal of 90%. The TP removal efficiency ranged from 12% to 96%, with an average removal of 64% (FDOH 2015).

In areas where septic systems are in close proximity to a surface waterbody but are not in a location where connection to the sewer system is feasible, adding BAM to the drainfield or upgrading to the passive nitrogen removing systems could be used to retrofit the existing septic systems. However, as of February 2018, permitting of such upgrades through the Florida Department of Health (FDOH) is held up in legal challenge. The estimated cost for these retrofits is $16,000 per septic system. Any operations and maintenance costs associated with these upgrades, once installed, will be the responsibility of the owner. To be conservative, the estimates of the TN reductions that could be achieved are based on an efficiency of 73.6% removal, which is the average efficiency from the two studies described above that tested BAM in the drainfield.

The cost to upgrade all 15,090 septic systems within 55 yards of an open water connection to the lagoon, which were not recommended for connection to sewer, would be $241,440,000. Therefore, these systems were further evaluated to prioritize those posing the greatest risk to IRL water quality. The criteria used were the distance from the groundwater table, soil types, year the property was developed, population density, and proximity to surface waters. These scoring criteria were a variation on the method used by Martin County to evaluate their septic systems. Brevard County Natural Resources Management, Utilities, and Department of Health staff met and agreed on how to modify the Martin County criteria to best fit Brevard County. Additional details about the scoring criteria are shown in **Table 26**. The results of this scoring provided information used to prioritize septic systems for upgrades.

The septic systems with the highest (worst) scores and within 55 yards of a surface waterbody are recommended for retrofit upgrades to reduce the impacts of these septic systems on the waterbodies. The number of these lots and the costs by sub-lagoon are shown in **Table 27**. The locations of these septic system upgrades are shown in **Figure 12**, **Figure 13**, and **Figure 14**. It is important to note that the septic system locations shown in the figures were based on the best available data from FDOH and the cities, and additional systems may be field verified and eligible for upgrade funding. This upgrade opportunity addresses 2.3% of the septic systems in the IRL drainage basin.

Funding for septic system connections and upgrades will be distributed to municipalities for projects within their jurisdiction for identified expansions of their sewer service areas, as appropriate.

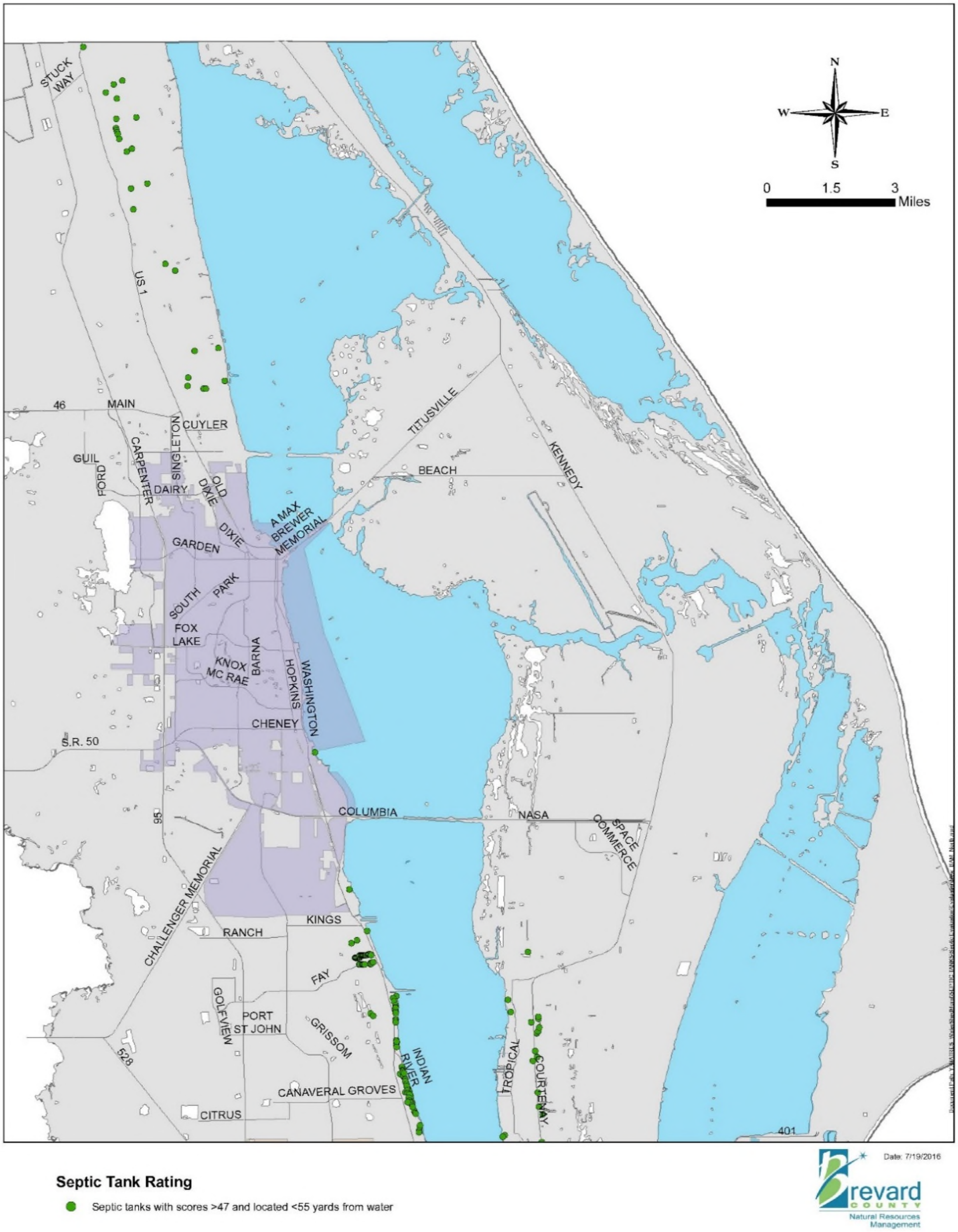
Table 26: Summary of Septic System Scoring Criteria

Evaluation Factors	Scores	Explanation
A - Groundwater Table (GWT)	0 points: GWT > 48 inches 8 points: GWT = 48 inches 12 points: GWT < 48 inches	These data were pulled from the USGS Soil Survey for Brevard County using Table 9 - *Estimates of Soil Properties,* Column titled "Depth to - Seasonal High Water Table."
B - Soil Types	0 points: Most ideal soils for drainfield performance 8 points: Moderate drainfield performance 12 points: Excessively or poorly drained soils	These data were scored by using the 2013 USGS Soil Survey for Brevard County using an average of scores from a table created by County staff. The scoring was based on an average of permeability following the Martin County example.
C - Surface Water Management Systems	4 points: Property developed after 1986 8 points: Property developed between 1980 and 1986 12 points: Property developed before 1980	These scores were derived by joining the property appraiser data to the scoring table and scoring based on the year built field.
D - Population Density	4 points: Low Density < 2 units per acre 8 points: Medium Density > 2-5 units per acre 12 points: High Density > 5 units per acre	The population density is the zoning of the parcel collected from Municode using "minimum expected density" for unincorporated county areas. Low Density = less than 2 units per acre, Medium Density = 2-5 units per acre, High Density = greater than 5 units per acre. Areas outside of unincorporated Brevard were scored using the size of the parcel (less than .2 acres = High Density, .2 to .5 = Medium and Greater than .5 acres = Low Density).
E - Proximity to Surface Waters	4 points: Properties greater than 219 yards from an open channel 8 points: Properties within 55 yards of any open channel 12 points: Properties with boundary along the Lagoon or within 20 feet of IRL shoreline	Identified parcels within 20 feet of the IRL; parcels between 55 yards and 219 yards of an open channel polyline; parcels greater than 219 yards from an open channel polyline.

Table 27: Septic Tank Upgrades and Costs for Highest Priority Septic Systems within 55 Yards of a Surface Waterbody

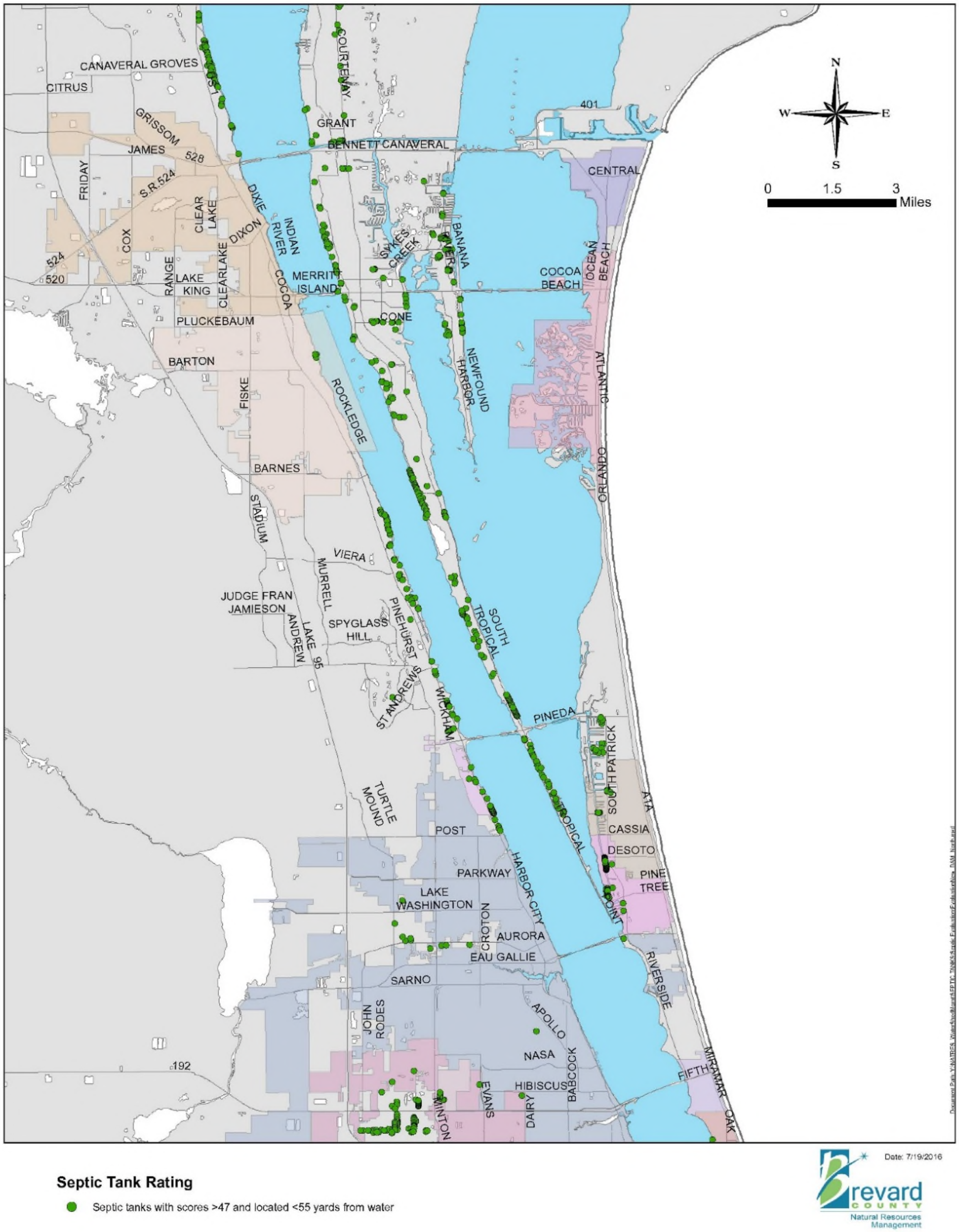
Sub-lagoon	Number of Lots	Cost	TN Load (lbs/yr)	TN Removal Efficiency	TN Reductions (lbs/yr)	Cost/lb/yr of TN
Banana River Lagoon	258	$4,128,000	6,991	73.6%	5,145	$802
North IRL	515	$8,240,000	13,954	73.6%	10,270	$802
Central IRL*	614	$9,824,000	16,636	73.6%	12,244	$802
Total	***1,387***	***$22,192,000***	***37,581***	***73.6%***	***27,659***	***$802***

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.
* The projects in the Central IRL sub-lagoon are located both in Zone A and Zone SEB (refer to **Section 2.1**).



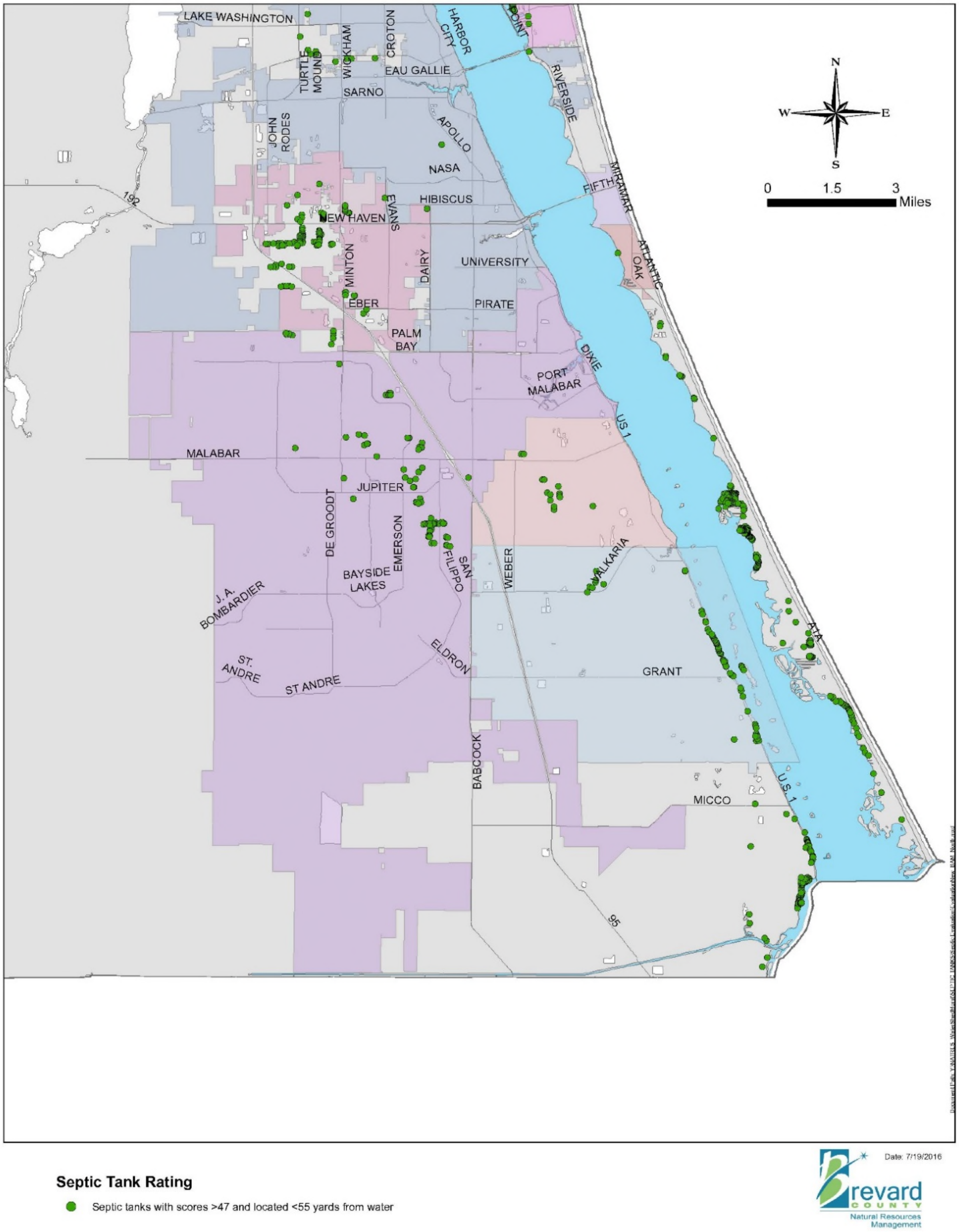
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time. County staff removed nearly 10,000 locations from FDOH maps based on confirmation data from municipalities for specific lots that have connected to sewer.

Figure 12: Map of Locations for Septic System Upgrades in North IRL



Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time. County staff removed nearly 10,000 locations from FDOH maps based on confirmation data from municipalities for specific lots that have connected to sewer.

Figure 13: Map of Locations for Septic System Upgrades in Banana River Lagoon and North IRL



Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time. County staff removed nearly 10,000 locations from FDOH maps based on confirmation data from municipalities for specific lots that have connected to sewer.

Figure 14: Map of Locations for Septic System Upgrades in Central IRL

4.1.5 Stormwater Treatment

Stormwater runoff contributes 33.6% of the external TN loading and 43.4% of the external TP loading to the lagoon annually.

Stormwater runoff from urban areas carries pollutants that affect surface waters and groundwater. These pollutants include nutrients, pesticides, oil and grease, debris and litter, and sediments. In Brevard County, there are more than 1,500 stormwater outfalls to the IRL.

There are a variety of BMPs that can be used to capture and treat stormwater to remove or reduce these pollutants before the stormwater runoff reaches a waterbody or infiltrates to the groundwater. Potential stormwater BMPs that could help restore the IRL system include:

- Traditional BMPs – These BMPs are the typical practices that are used to treat stormwater runoff and include wet detention ponds, retention, swales, dry detention, baffle boxes, stormwater reuse, alum injection, street sweeping, catch basin inserts/inlet filters, floating islands/managed aquatic plant systems (MAPS). Descriptions of these traditional BMPs and expected TN and TP efficiencies are shown in **Table 28**.
- Low impact development (LID)/green infrastructure (GI) – These types of BMPs use natural stormwater management techniques to minimize runoff and help prevent pollutants from getting into stormwater runoff. These BMPs address the pollutants at the source so implementing them can help decrease the size of traditional retention and detention basins and can be less costly than traditional BMPs (IFAS 2016). Descriptions of LID and GI BMPs and estimated efficiencies are shown in **Table 29**.
- Denitrification BMPs – These BMPs use a soil media, known as BAM to increase the amount of denitrification that occurs, which increases the amount of TN and TP removed. BAM includes mixes of soil, sawdust, zeolites, tire crumb, vegetation, sulfur, and spodosols. Additional details about denitrification BMPs are included below.
- BMPs to reduce baseflow intrusion – These projects are modifications to existing BMPs help reduce intrusion of captured groundwater baseflow into stormwater drainage systems. These BMPs include backfilling canals so that they do not cut through the baseflow, modifying canal cross-sections to maintain the same storage capacity while limiting the depth, installing weirs to control the water levels in the BMP, or adding a cutoff wall to prevent movement into the baseflow.
- Re-diversion to the St. Johns River – There are portions of the current IRL Basin that historically flowed towards the St. Johns River. By re-diverting these flows back to the St. Johns River, the excess stormwater runoff, as well as the additional freshwater inputs, to the IRL would be removed. The re-diversion projects would include a treatment component so that the runoff is treated before being discharged to the St. Johns River. SJRWMD has taken the lead on large-scale projects while the County has re-diverted more than 400 acres in the Crane Creek basin and partnered with SJRWMD to increase re-diversion from the Melbourne-Tillman Water Control District canal system.

Table 28: Traditional Stormwater BMPs with TN and TP Removal Efficiencies

BMP	Definition	TN Removal Efficiency	TP Removal Efficiency	Source
Wet detention ponds	Permanently wet ponds that are designed to slowly release a portion of the collected stormwater runoff through an outlet structure. Recommended for sites with moderate to high water table conditions. Provide removal of both dissolved and suspended pollutants through physical, chemical, and biological processes.	8%-44%	45%-75%	FDEP et. al. 2010
Off-line retention	Recessed area that is designed to store and retain a defined quantity of runoff, allowing it to percolate through permeable soils into the groundwater aquifer. Runoff in excess of the specified volume of stormwater does not flow into the retention system storing the initial volume of stormwater.	40%-84%	40%-84%	Harper et. al. 2007
On-line retention and swales	Recessed area that is designed to store and retain a defined quantity of runoff, allowing it to percolate through permeable soils into the groundwater aquifer. Runoff in excess of the specified volume of stormwater does flow through the retention system that stores the initial volume of stormwater.	30%-74%	30%-74%	Harper et. al. 2007
Dry detention	Designed to store a defined quantity of runoff and slowly release it through an outlet structure to adjacent surface waters. After drawdown of the stored runoff is completed, the storage basin does not hold any water. Used in areas where the soil infiltration properties or seasonal high water table elevation will not allow the use of a retention basin.	10%	10%	Harper et. al. 2007
2nd generation baffle box	Box chambers with partitions connected to a storm drain. Water flows into the first section of the box where most pollutants settle out. Overflows into the next section to allow further settling. Water ultimately overflows to the stormwater pipe. Floating trays capture leaves, grass clippings, and litter to prevent them from dissolving in the stormwater.	19.05%	15.5%	GPI 2010
Stormwater reuse	Reuse of stormwater from wet ponds for irrigation. Compare volume going to reuse to total volume of annual runoff to pond.	Amount of water not discharged annually	Amount of water not discharged annually	N/A
Alum injection	Chemical treatment systems that inject aluminum sulfate into stormwater systems to cause coagulation of pollutants.	50%	90%	Harper et. al. 2007
Street sweeping	Cleaning of pavement surfaces to remove sediments, debris, and trash deposited by vehicle traffic. Prevents these materials from being introduced into the stormwater system.	TN content in dry weight of material collected annually	TP content in dry weight of material collected annually	UF 2011
Catch basin inserts/inlet filters	Devices installed in storm drain inlets to provide water quality treatment through filtration of organic debris and litter, settling of sediment, and adsorption of hydrocarbon by replaceable filters.	TN content in dry weight of material collected annually	TP content in dry weight of material collected annually	UF 2011
MAPS	Aquatic plant-based BMPs that remove nutrients through a variety of processes related to nutrient uptake, transformation, and microbial activities.	20%	20%	FDEP et. al. 2010

Table 29: LID and GI BMPs and TN and TP Removal Efficiencies

BMP	Definition	TN Removal Efficiency	TP Removal Efficiency	Source
Permeable pavement	Hard, yet penetrable, surfaces reduce runoff by allowing water to move through them into groundwater below (IFAS 2016).	30%-74%	30%-74%	Harper et. al. 2007
Bioswales	An alternative to curb and gutter systems, bioswales convey water, slow runoff, and promote infiltration. Swales may be installed along residential streets, highways, or parking lot medians (IFAS 2016). Must be designed for conveyance, greater in length than width, have shallow slopes, and include proper landscaping.	38%-89%	9%-80%	FDEP 2014
Green roofs	These systems can significantly reduce the rate and quantity of runoff from a roof and provide buildings with thermal insulation and improved aesthetics (IFAS 2016). Retention BMP covered with growing media and vegetation that enables rainfall infiltration and evapotranspiration of stored water. Including a cistern capture, retain, and reuse water adds to effectiveness.	45% (without cistern) 60%-85% (with cistern)	N/A	FDEP 2014
Bioretention basins/rain gardens	Small vegetated depressions in the landscape collect and filter stormwater into the soil (IFAS 2016). Constructed adjacent to roof runoff and impervious areas.	30%-50%	30%-90%	FDEP 2014
Tree boxes	Bioretention systems with vertical concrete walls designed to collect/retain specified volume of stormwater runoff from sidewalks, parking lots and/or streets. Consists of a container filled with a soil mixture, a mulch layer, under-drain system, and shrub or tree (FDEP 2014).	38%-65%	50%-80%	FDEP 2014

Due to the importance of treating dry season baseflow to the lagoon, Brevard County has found that ditch denitrification is the most cost-effective BMP. BAM can be added in existing BMPs or to new BMPs to improve the nutrient removal efficiency. The removal efficiencies of using BAM in various stormwater treatment projects (Wanielista 2015) are summarized in **Table 30**.

Table 30: TN and TP Removal Efficiencies for BAM

Location in BMP Treatment Train	Material	TN Removal Efficiency	TP Removal Efficiency
Bold & Gold as a first BMP, ex. Up-flow filter in baffle box and a constructed wetland	Expanded Clay Tire Chips	55%	65%
Bold & Gold in up-flow filter at wet pond and dry basin outflow	Organics Tire Chips Expanded Clay	45%	45%
Bold & Gold in inter-event flow using up-flow filter at wet pond and down-flow filter at dry basin	Expanded Clay Tire Chips	25%	25%
Bold & Gold down-flow filters 12" depth at wet pond or dry basin pervious pavement, tree well, rain garden, swale, and strips	Clay Tire Crumb Sand & Topsoil	60%	90%

Note: From Wanielista 2015

The County's proposed TMDLs include two components: (1) a TMDL for the five-month period (January – May) that is critical for seagrass growth, and (2) a TMDL for the remaining seven months of the year to avoid algal blooms and protect healthy dissolved oxygen levels. The stormwater project benefits were estimated, as follows, to ensure both components of the TMDL are adequately addressed. The five-month TMDL covers the dry season in this area when there is minimal rainfall and stormwater runoff; therefore, the benefits of stormwater BAM projects during this period were based only on January – May baseflow loading estimates from the SWIL model. The estimated project treatment efficiencies used for January to May are 55% for TN and 65% for TP. For the remaining seven months, the baseflow and stormwater loading estimates from the SWIL model were used with a project efficiency of 45% for TN and 45% for TP. The estimated TN and TP reductions accomplished by using BAM upstream of these priority outfalls are summarized in **Table 31**, as well as the estimated cost per pound of TN or TP removed. A detailed list of stormwater projects is included in **Appendix D**. The locations of the basins to be treated are shown in **Figure 15**, **Figure 16**, and **Figure 17**.

Table 31: Estimated TN and TP Reductions and Costs for BAM Projects

Sub-lagoon	Number of Basins	Estimated Total Project Cost	TN Reductions (lbs/yr)	Cost/lb/yr of TN	TP Reductions (lbs/yr)	Cost/lb/yr of TP
Banana River Lagoon	41	$4,625,000	48,391	$96	6,896	$671
North IRL	37	$4,850,000	52,936	$92	7,632	$635
Central IRL	4	$900,000	11,709	$77	1,774	$507

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

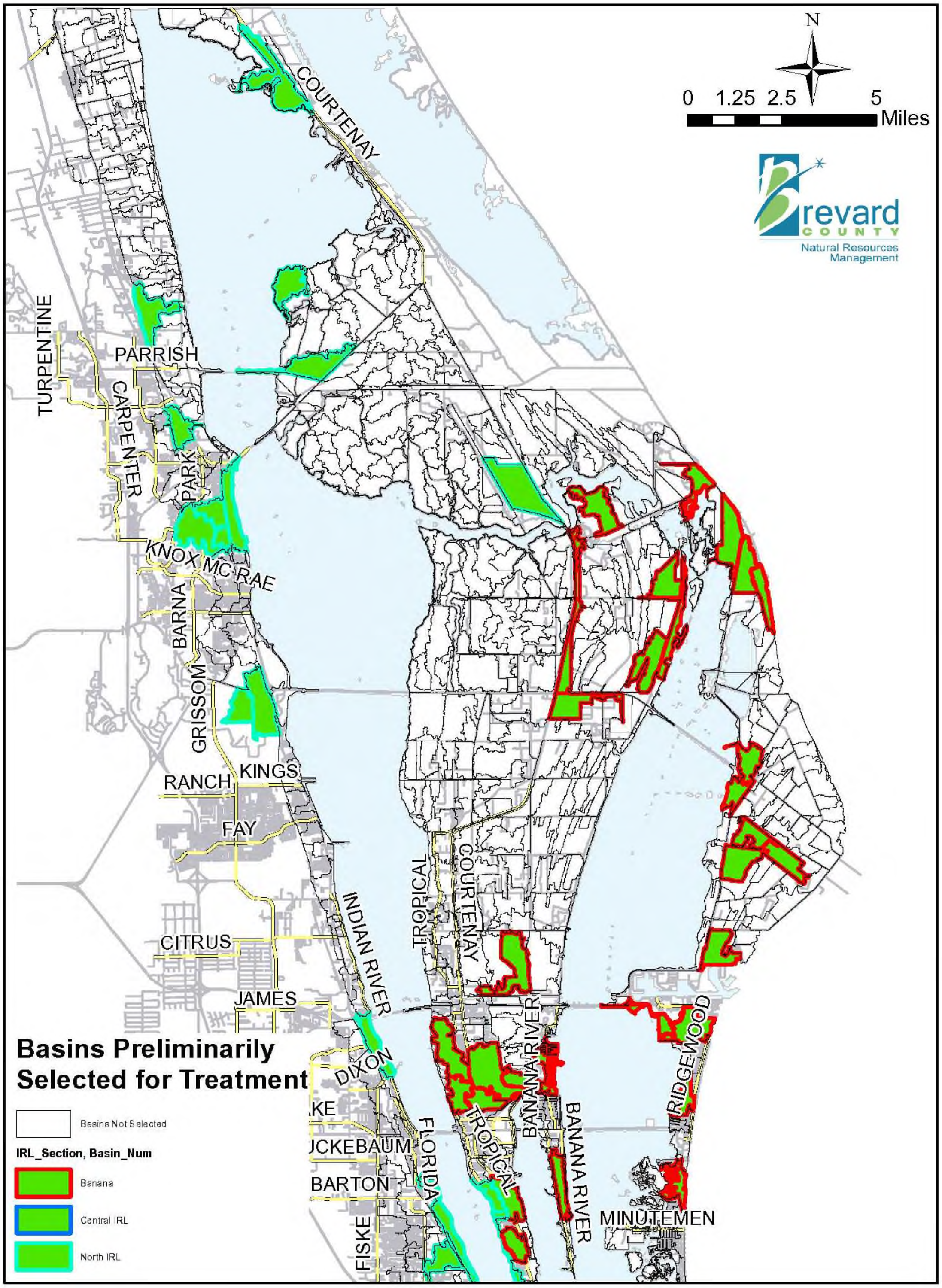


Figure 15: Map of Selected Stormwater Projects in Banana River Lagoon and North IRL

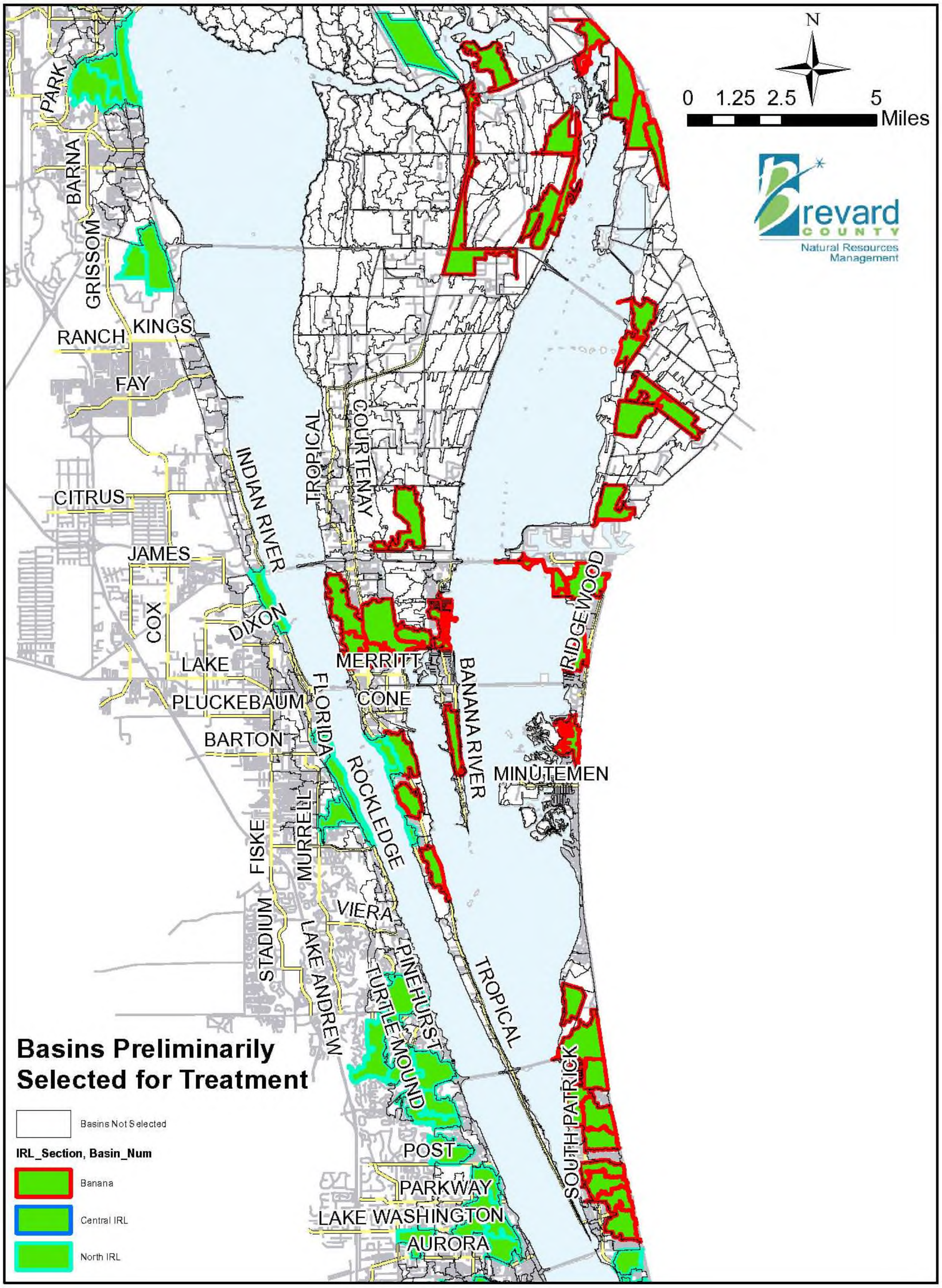


Figure 16: Map of Selected Stormwater Projects in Banana River Lagoon and North IRL, continued

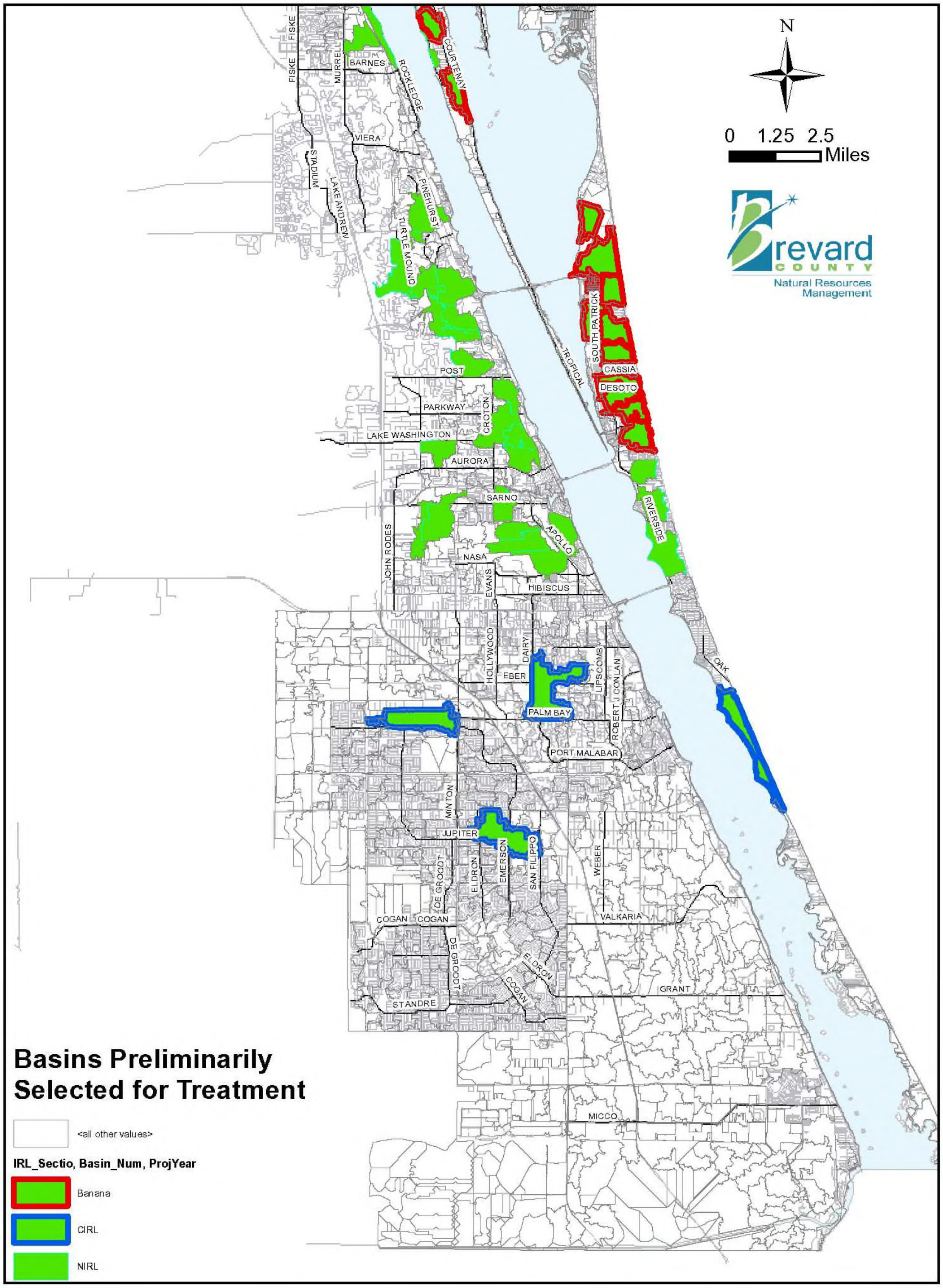


Figure 17: Map of Selected Stormwater Projects in North IRL and Central IRL

4.1.6 Surface Water Remediation System

AquaFiber Technologies Corporation has a technology that would treat up to 25 cubic feet per second (16 mgd) of water from Turkey Creek, which is a major tributary to the Central IRL. This project would reduce total suspended solids by more than 90%, remove algal blooms and cyanobacteria to improve the lagoon's color and clarity, improve the dissolved oxygen concentration by returning water with near 100% oxygen saturation, and produce a biomass that can be processed into fertilizer pellets or used as a feedstock for waste-to-energy utilities to produce electricity.

This project would remove an estimated 35,633 lbs/yr of TN and 2,132 lbs/yr of TP from the watershed. The facility would cost $19,720,760 for design, permitting, construction, and use of a technology to destroy the biomass onsite. The cost to operate and maintain the remediation facility is estimated to be $6,271,200 per year. **Table 32** summarizes the benefits and the costs of nutrient removal for this project for a 10-year period. On an annual basis, the yearly costs would be $8,243,276, which would result in a cost/lb/yr of TN removed of $231 and cost/lb/yr of TP removed of $3,867.

Table 32: Summary of Benefits and Costs of Central IRL Surface Water Remediation System

Project Cost	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Cost/lb/yr of TN Removed	Cost/lb/yr of TP Removed
$82,432,760	35,633	2,132	$2,313	$38,665

The cost of nutrient removal via this technology is higher than the cost per pound removed for the other projects recommended in this plan; therefore, this remediation system is not recommended in the first iteration of this plan. However, this technology offers significant additional benefits that should be more thoroughly explored to better assess its total value to restoring and maintaining lagoon health.

4.2. Projects to Remove Pollutants

The projects in this section will be implemented to remove pollutants that have accumulated in the lagoon. Brevard County has already begun to remove deep accumulations of muck from the lagoon bottom, and dredging to remove muck in other locations of the lagoon will continue. In addition, SJRWMD is evaluating opportunities for artificial flushing projects, which will allow additional water to flow into the lagoon system to flush out the built-up sediments and muck. These muck removal projects have more immediate benefits on the lagoon water quality than external reduction projects because the nutrient flux is reduced as soon as muck is dredged or flushed from the system whereas it takes time for the external load reduction benefits to reach the lagoon.

The following sections describe the County's proposed muck removal projects, as well as SJRWMD's research into artificial flushing projects. The artificial flushing projects are not proposed for inclusion in this funding plan.

4.2.1 Muck Removal

Muck flux contributes 1,282,000 lbs/yr of TN and 192,400 lbs/yr of TP to the lagoon.

The muck in the lagoon increases turbidity, inhibits seagrass growth, promotes oxygen depletion in sediments and the water above, stores and releases nutrients, covers the natural bottom, and destroys healthy communities of benthic organisms (Trefry 2013). When muck is suspended within the water column due to wind or human activities such as boating, these suspended solids limit light availability and suppress seagrass growth. Even for deeper water areas without seagrass growth, muck remains a nutrient source that potentially affects a broader area of the lagoon through nutrient flux and resuspension of fine sediments and their subsequent transport. As shown in **Figure 4**, the annual release of nutrients from decaying muck is almost as much as the annual external loading delivered by stormwater and groundwater baseflow combined. The muck deposits cover an estimated 15,900 acres of the lagoon system bottom in Brevard County (Trefry 2016).

The muck deposits in the lagoon flux nutrients that enter the water column and contribute to algal blooms and growth of macroalgae. Muck flux rates for nitrogen and phosphorus have been estimated through studies in the IRL system. For this plan, the flux rates used are 89 pounds of TN/yr/acre and 13.4 pounds of TP/yr/acre (Trefry 2016).

The focus of the muck removal projects for this plan was on large deposits of muck in big, open water sites within the lagoon itself. Several of the main canals that directly connect to the lagoon are also included for muck removal. The goal of the muck removal is to reduce TN and TP muck flux loads by 25%, which should result in a significant improvement in water quality and seagrass extent, as well as a reduced risk of massive algal blooms and fish kills. A 70% efficiency for muck removal projects was applied. This efficiency accounts for two factors: (1) each target dredge area has less than 100% muck cover, and (2) some pockets of muck within dredged areas will inevitably be left behind regardless of the dredge technology used. Based on a 25% target reduction and 70% efficiency for dredging, the muck area reduction targets for this plan were established as shown in **Table 33**.

Table 33: Muck Acreages in the IRL System

Muck Reduction Targets	Open Banana River Lagoon	Banana River Lagoon Canals	North IRL	Central IRL	Mosquito Lagoon
Muck area (acres)	4,646	474	7,364	1,853	1,582
Area to reduce flux by 25% (acres)	1,161	119	1,841	465	395
Area dredged to reduce flux by 25% with 70% project efficiency (acres)	***1,656***	***173***	***2,619***	***667***	***565***

The costs for the proposed muck dredging projects are shown in **Table 34** for the Mosquito Lagoon, **Table 35** for the North IRL, **Table 36** for the Banana River Lagoon, and **Table 37**. The locations of these projects are shown in **Figure 18** and **Figure 19**. Using the flux rates noted in **Section 4.2.1**, the estimated TN and TP reductions that can be achieved from removing the muck, as well as the cost per pound of nutrient removed, were determined (see **Table 38**).

Table 34: Mosquito Lagoon Estimated Costs for the Proposed Muck Removal Projects

Location	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Near Haulover Canal	398	460,000	$16,100,000

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 35: North IRL Estimated Costs for Proposed Muck Removal Projects

Location	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Titusville Area	528	650,000	$22,750,000
Cocoa Area	288	400,000	$14,000,000
Rockledge Area	81	100,000	$3,500,000
Eau Gallie Area	750	650,000	$22,750,000
Venetian Canals/Channels	11	50,000	$1,750,000
North IRL Total	***1,658***	***1,850,000***	***$64,750,000***

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 36: Banana River Lagoon Estimated Costs for the Proposed Muck Removal Projects

Location	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Cape Canaveral Area	865	750,000	$26,250,000
Cocoa Beach Area	1243	1,150,000	$40,250,000
Newfound Harbor Area	245	225,000	$7,875,000
Pineda Causeway Area	163	150,000	$5,250,000
Mathers Bridge Area	190	175,000	$6,125,000
Venetian Canals/Channels	213	750,000	$26,250,000
Banana River Total	***2,918***	***3,200,000***	***$112,000,000***

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 37: Central IRL Estimated Costs for the Proposed Muck Removal Projects

Location	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Melbourne Causeway Area	15	20,000	$700,000
Goat Creek Area	5	5,000	$175,000
Trout Creek Area	5	5,000	$175,000
Mullet Creek Islands Area	76	70,000	$2,450,000
Venetian Canals/Channels	11	50,000	$1,750,000
Central IRL Total	***113***	***150,000***	***$5,250,000***

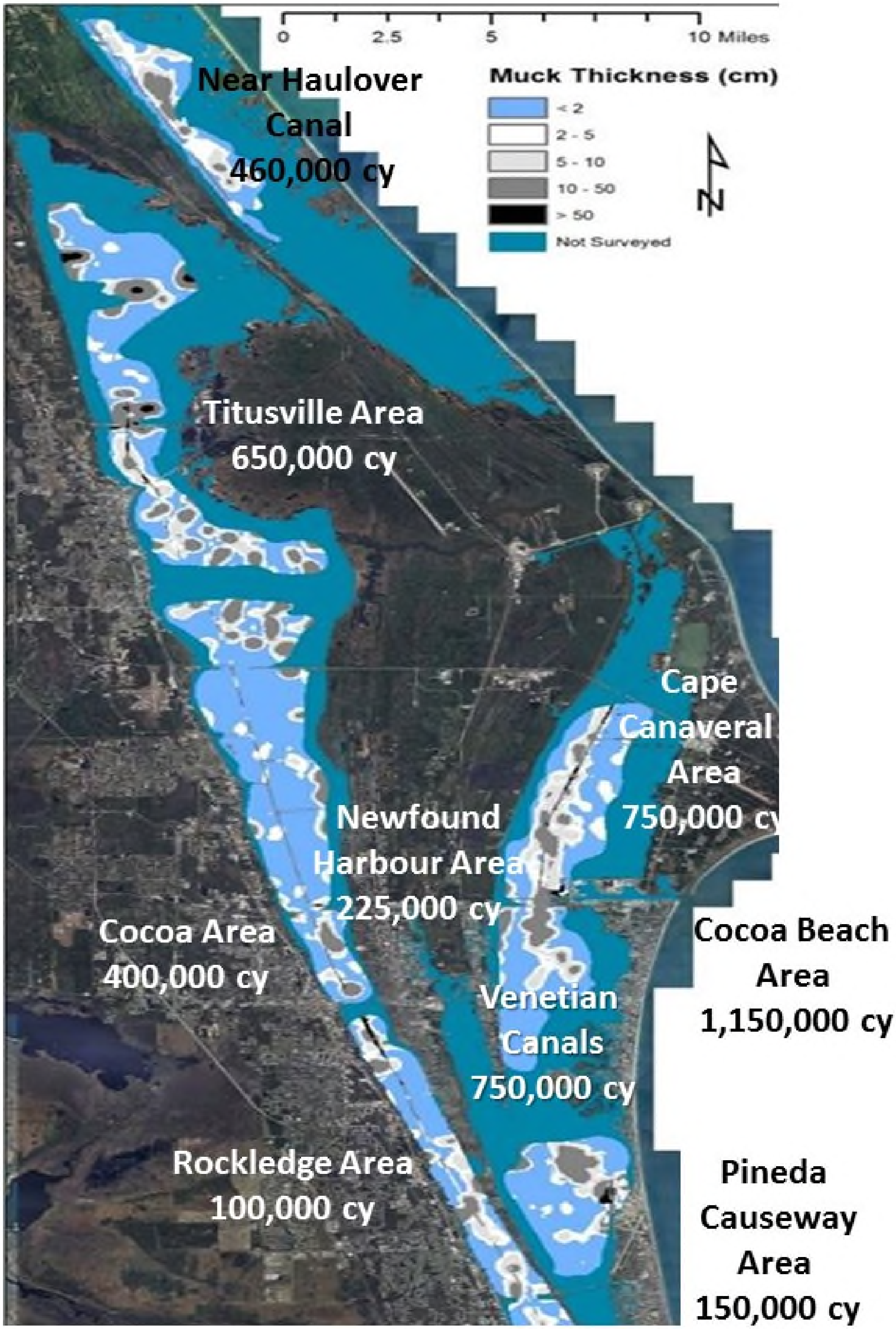
Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 38: Nitrogen and Phosphorus Reductions from Muck Removal

Location	Project Cost	TN Flux Reduction (lbs/yr)	Cost/lb/yr of TN Removed	TP Flux Reduction (lbs/yr)	Cost/lb/yr of TP Removed
Mosquito Lagoon	$16,100,000	35,000	$460	5,250	$3,067
North IRL	$64,750,000	147,913	$438	22,220	$2,914
Banana River Lagoon	$112,000,000	260,315	$430	39,106	$2,864
Central IRL	$5,250,000	10,052	$522	1,510	$3,477

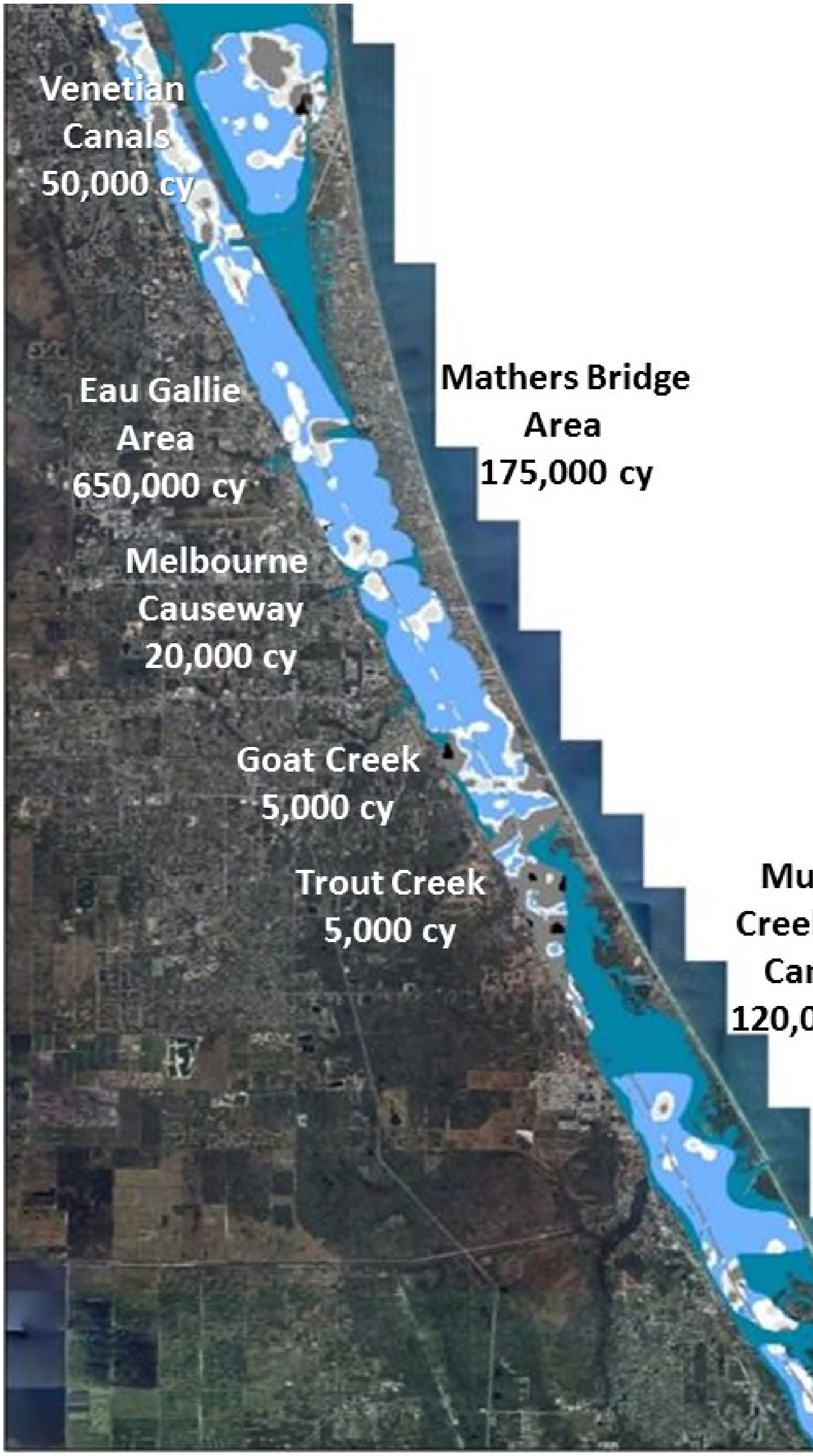
Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

As dredging proceeds, upland input of muck components must be reduced to prevent new muck accumulation. Therefore, land-based source control measures for nutrients, organic waste, and erosion are needed. Without source controls, muck removal will need to be frequently repeated, which is neither cost-effective nor beneficial to the lagoon's health. Public awareness and commitment is needed to control future muck accumulation. Activities that contribute organic debris and sediment to stormwater and open water must be curtailed. Additional scientific assessment should be carried out to evaluate and optimize the dredging process.



Note: Map is from SJRWMD for informational purposes only and is based on data from 2014. Annotation of project areas by County staff working with muck research scientists.

Figure 18: Location of Potential Muck Removal Projects in Mosquito Lagoon, Banana River Lagoon, and North IRL



Note: Map is from SJRWMD for informational purposes only and is based on data from 2014. Annotation of project areas by County staff working with muck research scientists.

Figure 19: Location of Potential Muck Removal Projects in North IRL and Central IRL

Treatment of Muck Interstitial Water (added in 2018)

Interstitial water refers to the water content that is present within the muck material. Sampling and testing conducted by Florida Institute of Technology researchers has shown that the majority of nutrients are bound to solid particles in the muck; however, the interstitial water also contains a significant amount of dissolved nutrients. When the muck material is dredged, interstitial water nutrients are pumped with the muck and lagoon water in a slurry to the dredged material management area (DMMA). At the DMMA, the muck slurry is processed in a settling pond where sediments settle out and overflow water is returned to the IRL. Treatment of this overflow water represents a significant opportunity to prevent return of these nutrients to the IRL.

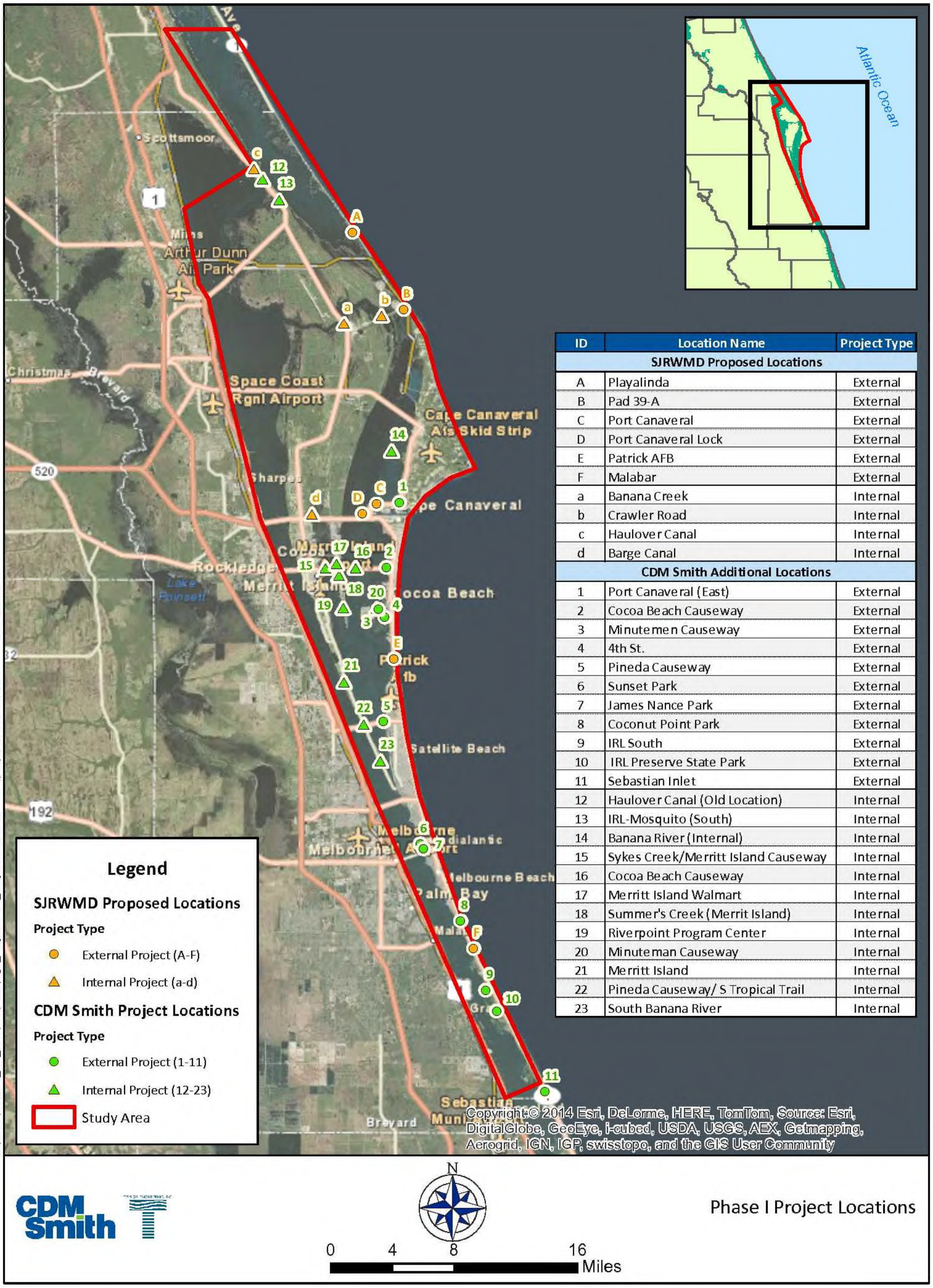
Working with the dredging industry, sewage treatment industry, stormwater treatment entrepreneurs and industrial waste treatment engineers, feasible and reasonably cost-effective concentration targets for return water to the IRL have been identified as 2,000–3,000 parts per billion (ppb) for TN and 75–100 ppb for TP. Treatment options were demonstrated during the state-funded initial dredging of Turkey Creek, with Florida Institute of Technology researchers providing independent third-party verification of performance levels. These targets can be achieved through a variety of technologies including, but not limited to, coagulants, polymers, BAM, or a combination of these technologies. Costs associated with these technologies vary by technology, target nutrient reduction levels, and interstitial nutrient concentrations. Open market costs were collected through two bid solicitations: (1) Mims Boat Ramp muck removal project and (2) Sykes Creek muck removal project.

To encourage partnering entities and applicants for Save Our Indian River Lagoon Trust Fund dollars to take advantage of this opportunity to enhance the performance of muck removal projects by removing interstitial water nutrients from the dredge slurry during muck dredging operations whenever project configuration allows, a separate cost-share has been developed to account for this added cost and associated nutrient reduction benefit. Using available cost information from Turkey Creek, Mims, and Sykes Creek, County staff considered how to incentivize the addition of this processing step as soon as possible into permitted muck removal projects, as well as future projects. Staff estimated that a cost-share of $175/lb of TN removed would be sufficient to entice most partners to agree to stipulate a specific condition in their bids and dredging contracts that return water not exceed 3,000 ppb of TN nor 100 ppb of TP. The cost-share of $175/lb of TN is also within the range of costs provided for nutrient mitigation alternatives for sediment dewatering for Turkey Creek (Tetra Tech 2015).

4.2.2 Artificial Flushing

The 2011 superbloom occurred in the Banana River Lagoon, North IRL, and southern Mosquito Lagoon. These areas have long residence times, which means that water in these areas is not flushed out often and nutrients can build up leading to additional algal blooms. One option to help this condition is to increase the flushing by adding culverts or inlets to provide new connections to the ocean or within the IRL system to artificially increase flushing. However, artificial flushing projects have a lot of unknowns. While the flushing of the IRL system increases, the input of additional saltwater has the potential to affect the lagoon ecosystem. The amount of flushing needed to have a beneficial impact on the system without causing harm is also unknown. These projects are costly with permitting hurdles that must be overcome. For these reasons, artificial flushing projects are not a recommended component of this plan. However, this type of project is a potential option for restoring the lagoon and SJRWMD is taking the lead on evaluating options. The results of their evaluation to date are summarized below.

SJRWMD contracted with CDM Smith and Taylor Engineering to identify potential locations where artificial flushing projects would be beneficial. The first phase of the project (CDM Smith et. al., 2014) involved a literature review and Geographic Information System (GIS) desktop analysis. All of the locations considered in Phase I, including the top ranked locations, are shown in **Figure 20**. From this first phase, ten locations were identified for future evaluation as shown in **Table 39**. The external projects are those that could potentially connect the IRL system with the Atlantic Ocean whereas internal projects are connections within the IRL (CDM Smith et. al., 2015).



Source: CDM Smith et. al., 2015.

Figure 20: Phase I Potential Artificial Flushing Project Locations

Table 39: Phase I Top Ranked Potential Artificial Flushing Project Locations

Project Site ID	Project Description	Zone	Project Type	Rank
D	Canaveral Lock*	Banana River Lagoon	External	1
C	Port Canaveral*	Banana River Lagoon	External	2
15	Sykes Creek/Merritt Island Causeway*	Banana River Lagoon	Internal	3
B	Pad 39-A*	Banana River Lagoon	External	4
16	Cocoa Beach Causeway	Banana River Lagoon	Internal	5
23	South Banana River	Banana River Lagoon	Internal	6
E	Patrick AFB*	Banana River Lagoon	External	7
20	Minuteman Causeway	Banana River Lagoon	Internal	8
1	Port Canaveral (East)	Banana River Lagoon	External	9
8	Coconut Point Park*	Central and Southern Portion of IRL Study Area	External	10

Source: CDM Smith et. al., 2015.
* Sites evaluated in Phase 2 of the CDM Smith and Taylor Engineering project for SJRWMD.

As part of the second phase of the project, six of the top ranked sites were further evaluated to assess the flushing volumes. These sites are noted in **Table 39**. Based on the initial evaluation of the sites, CDM Smith and Taylor Engineering determined that a project at the Sykes Creek/Merritt Island Causeway was not feasible. This location had a relatively new bridge crossing with built-up abutment protection that precludes construction of culverts and the increase of bridge openings. In addition, this connection would only provide an internal connection in the IRL and would not increase the tidal exchange. The five remaining sites were evaluated for the following types of connections (additional information in **Table 40**):

- Port Canaveral (Project Site C) – Culvert connection
- Pad 39-A (Project Site B) – Culvert connection
- Patrick AFB (Project Site E) – Culvert connection
- Canaveral Lock (Project Site D) – Open channel flow by keeping the Canaveral Lock open over extended periods. Additional maintenance dredging may be needed to remove sediment deposition near the gates.
- Coconut Point Park (Project Site 8) – Culvert connection
- Coconut Point Park (Project Site 8) – Inlet connection with an inlet that is at least 1,350-feet long, with an average depth of about 25 feet below mean sea level.

Table 40: Computed Hydraulics for Connections at Select Locations

Site/Potential Project	Flood Prism (million cubic ft)	Ebb Prism (million cubic ft)	Maximum Flow (cfs)	Estimated Impacted Area for 0.27 ft Tide Range (acres)
Port Canaveral Culvert (Project Site C)	1.51	-1.08	89	92 to 128
Pad 39-A Culvert (Project Site B) (estimated)	1.38 to 1.51	-1.08 to -1.59	N/A	92 to 135
Patrick AFB Culvert (Project Site E) (estimated)	1.38 to 1.51	-1.08 to -1.59	N/A	92 to 135
Canaveral Lock Open Channel Flow (Project Site D)	68.67	-83.03	-4,670	5,839 to 7,060
Coconut Point Park Culvert (Project Site 8)	1.38	-1.59	-94	117 to 135
Coconut Point Park Inlet (Project Site 8)	1,890	N/A	111,000	160,698

Source: CDM Smith et. al., 2015.
Note: Positive flow is towards the IRL.

A screening matrix was used to evaluate the costs and benefits of the project based on the criteria for the tidal prism, area affected, land acquisition, relative costs, ease of construction, seagrass loss, and benefit to cost ratio. The top ranked project from this evaluation is the Port Canaveral culvert (CDM et. al., 2015). It is important to note that a culvert will likely not provide the amount of flushing needed to provide a significant benefit to the lagoon. The size of the lagoon in Brevard County is more than 150,000 acres. The second ranked project is the Canaveral Lock open channel. This option may have challenges moving forward based on past experience with sediment blocking submarines from using the port after the lock was held open for an extended period of time. In addition, there are limited data for estimating the water quality benefits and unintended ecological consequences that could result from keeping the lock open.

Another potential option for adding flushing in the lagoon system is when a large storm creates an opening. Instead of immediately filling in the new opening, an evaluation should be completed using available flushing models to determine the potential benefits of temporarily stabilizing the opening long enough to provide significant ocean exchange for short-term water quality benefits, but not long enough to excessively alter beach erosion and sand transport into the lagoon.

4.3. Projects to Restore the Lagoon

Another component of this plan is to implement projects that will restore important, filtering ecosystem services within and adjacent to the lagoon to improve water quality and resilience. Creating oyster reefs and living shorelines made up of oysters and natural vegetation will help to filter excess nutrients and suspended solids from the lagoon, which will improve water quality, allowing for seagrass growth and reducing the number and severity of algal blooms in the lagoon system. Oyster reefs and living shorelines also create habitat for more than 300 different lagoon species. These types of projects take a few years before the full benefits are seen in the lagoon as it takes some time for the oysters and vegetation to grow and become established. As water quality improves, oysters will filter a greater volume annually, increasing natural resilience to extreme events and algal blooms.

The sections below summarize the oyster restoration and living shoreline projects that are proposed, as well as considerations for seagrass planting.

4.3.1 Oyster Restoration

The primary mechanism by which oyster reefs remove nitrogen is by increasing local denitrification rates.

In addition to the fisheries value of oysters, they provide a variety of nonmarket ecosystem services. Restored oyster reefs have been shown to result in a positive net effect on the removal and sequestration of nitrogen compared to unrestored sites. As nitrogen is a major contributor to algal blooms and turbidity, removal of nitrogen from the system often yields water quality benefits. The nitrogen is removed through three pathways: (1) assimilation of the nitrogen in the shell and tissues of the oysters, (2) enhanced burial of nitrogen into the sediments surrounding oyster reefs, and (3) conversion to gaseous form with return to the atmosphere through microbe-related denitrification (zu Ermgassen 2016).

The primary mechanism by which oyster reefs remove nitrogen from the system is by increasing local denitrification rates (Grabowski et. al. 2012). While oyster reefs have a relatively small impact on average nutrient concentrations for an entire waterbody, their local impact may be much larger. For example, in a study by Kroeger (2012), it was noted that the eastern section of Mobile Bay had experienced harmful algal blooms that caused fish kills. These conditions occur in the summer months when denitrification by restored oysters would be highest. Therefore, the nitrogen removal associated with the oyster reef project in the bay may make a noticeable contribution to the local water quality by avoiding peak nitrogen concentrations that may trigger algal blooms. In a study by Kellogg et. al. (2013), the denitrification rates associated with oyster reefs from various studies were documented. Based on these studies, the average effect of denitrification rate is 291 µmol N/m^2/hr, which equates to 0.04 lbs N/m^2/yr (161.9 lbs N/ac/yr). A more recent study was conducted in the Mosquito Lagoon to determine the local benefits from oyster bed restoration. This study found that the average denitrification rate and measured nitrogen sequestration in oyster tissues and shells is 0.04 lbs of TN/square foot (Schmidt and Gallagher 2017).

The focus for oyster restoration in the IRL system is to provide filtration, sequestration, denitrification, and scour protection along the shoreline (see **Section 4.3.2** for details on scour protection). The goal is not to restore historic oyster reefs in the system because information is not available on where oyster reefs were historically located. In addition, large-scale reefs would compete for space with seagrass, and seagrass are a more critical component of the system. Therefore, the reefs that will be constructed will be shaped as narrow bars and placed along the shoreline, shallower than the typical depths for seagrass, to act as a living wave break along the shoreline. The benefits of oyster reefs as a living shoreline are shown in **Section 4.3.2**.

Most of the IRL system in Brevard County no longer has a sufficient oyster population to allow for natural recruitment of oysters to suitable substrate. Therefore, to create the oyster reefs, the oysters must be grown and then carefully placed on appropriate substrate in the selected locations. To help grow the oyster population, in FY2013-2014, the Board of County Commissioners approved $150,000 to launch the Oyster Gardening Program. This program is a citizen-based oyster propagation program where juvenile oysters are raised under lagoon-front homeowners' docks and eventually used to populate constructed oyster reef sites. Oyster Gardening participants receive spat-on-shell oysters plus all supplies needed to care for their oysters until six to nine months later when they are placed at new reef sites in the lagoon. The Oyster Gardening Program is executed in partnership with the Brevard Zoo. The project continued during FY2014-2015 with funding from the state and in FY2015-2016 with funding from the County. The County plans to continue funding this program annually.

The oysters from the Oyster Gardening Program have been used to develop several pilot reefs and demonstration sites in the IRL. In FY 2014-2015, the County received a $410,000 appropriation from the Florida Legislature for the Indian River Lagoon Oyster Restoration Project. This pilot study was completed in fall 2016. The design of oyster wave breaks funded by the Save Our Indian River Lagoon tax is based on monitoring results from the pilot reefs and wave tank studies at Florida Institute of Technology that tested the reef stability and wave attenuation of different designs.

4.3.2 Living Shorelines

Typically, efforts to protect shorelines have involved hardened structures, such as seawalls, rock revetments, or bulkheads, to dampen or reflect wave energy. Although these types of structures may mitigate shoreline retreat, they accelerate scour and the ecological damages that result can be great (Scyphers et. al. 2011). The living shoreline approach incorporates natural habitats into a shoreline stabilization design; maintains the connectivity between aquatic, intertidal, and terrestrial habitats; and minimizes the adverse impacts of shoreline stabilization on the estuarine system. These efforts range from maintaining or transplanting natural shoreline vegetation without additional structural components to incorporating shoreline vegetation with hardened features, such as rock sills or oyster bars, in settings with higher wave energy (Currin et. al. 2010). Selection of the most appropriate management system begins with a site analysis to evaluate the type of shoreline, amount of energy that a shoreline experiences, sediment transport forces, type and location of ecological resources, and adjacent land uses (Restore America's Estuaries 2015).

Oyster reefs can function as natural breakwaters, in addition to providing nutrient removal benefits through denitrification, as noted in **Section 4.3.1**. The rate of vertical oyster reef growth on unharvested reefs is far greater than any predicted sea-level rise rate; therefore, reefs could serve as natural protection against shoreline erosion, intertidal habitat loss, and property damage and loss along many estuarine shorelines. Oyster reefs reduce erosion of other estuarine habitats such as salt marshes and submerged aquatic vegetation by serving as a living breakwater that attenuates wave energy and stabilizes sediments (Grabowski et. al. 2012).

As part of a study for the Chesapeake Bay, Forand et. al. (2014) evaluated the pollutant load reductions from living shoreline projects in the area. The results of this evaluation are shown in **Table 41**, and were used to update the U.S. Environmental Protection Agency Chesapeake Bay Program Office (CBPO) estimate of the TN and TP reductions per foot of living shoreline. It is important to note that the information in this table is from states up north where temperatures become much cooler for longer periods of time than what occurs in Brevard County. Therefore, the benefits associated with vegetated living shorelines in the IRL system will likely be greater than those estimated here.

Table 41: Pollutant Load Reductions for Shoreline Management Practices

Source	TN (lb/ft/yr)	TP (lb/ft/yr)	Study Location
Ibison, 1990	1.65	1.27	Virginia
Ibison, 1992	0.81	0.66	Virginia
Proctor, 2012	N/A	0.38 or 0.29	Virginia
MDE, 2011	0.16	0.11	Maryland
Baltimore County mean (Forand, 2013)	0.27	0.18	Maryland
CBPO Scenario Builder (CBP, 2012)	0.02	0.0025	CBP policy threshold that comes from one stream restoration site in Maryland
New Interim CBPO Rate (Expert Panel, 2013)	***0.20***	***0.068***	***CBPO policy thresholds that comes from six stream restoration sites***

Note: Table is from Forand et. al. 2014.

Brevard County

In order to create enough oyster reef area to filter the volume of lagoon water annually, approximately 20 miles (105,600 feet) of oyster reef living shoreline is needed with a width of 6 feet. These reefs will be placed throughout the IRL system along mosquito impoundments, parks, and private properties where owners want to participate. Based on the pilot project costs and knowing that larger reefs will be constructed more efficiently (using information from the pilot projects), it is estimated that the 20 miles of living shoreline could be constructed at a cost of $10 million. The resulting reefs would provide a reduction of 21,120 lbs/yr of TN and 7,181 lbs/yr of TP (see **Table 42**).

Table 42: Initial Estimated Oyster Reef Living Shoreline TN and TP Reductions and Costs

Project	Total Length (feet)	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)	Cost Estimate	Cost/lb/yr of TN Reduction	Cost/lb/yr of TP Reduction
Oyster reef living shorelines	105,600	21,120	7,181	$10,000,000	$473	$1,393

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

With the recent study on oyster reefs in the IRL system (Schmidt and Gallagher 2017), the benefits associated with oyster reefs versus vegetative living shorelines could be delineated. For the proposed oyster reef along 20 miles (105,600 feet) of shoreline with a width of 6 feet (total of 633,600 square feet of oyster reef, the estimated reductions are 25,539 lbs/yr of TN and 906 lbs/yr of TP (see **Table 43**). These estimates are based on the estimated TN reduction rate of 0.04 lbs of TN/square foot of oyster reef from Schmidt and Gallagher 2017 and the estimated TP reduction rate of 0.001 lbs of TP/square foot of oyster reef from Kellogg et. al. 2013.

Table 43: 2018 Updated Estimated Oyster Reef TN and TP Reductions and Costs

Project	Total Area (square feet)	Cost Estimate	TN Reductions (lbs/yr)	Cost/lb/yr of TN Reduction	TP Reductions (lbs/yr)	Cost/lb/yr of TP Reduction
Oyster reefs	633,600	$10,000,000	25,539	$392	906	$11,034

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

In addition, if 20 miles of shoreline (105,600 feet) were planted with native vegetation in living shorelines at a width of 8 feet (total of 844,800 square feet of living shoreline), the total estimated cost is $1,267,200 with a reduction of 7,040 lbs/yr of TN and 2,394 lbs/yr of TP (**Table 44**). The estimated nutrient reductions from vegetative shoreline buffers was calculated using Chesapeake Bay Program Office recommended rates of 0.02 lbs of TN/linear foot and 0.068 lbs of TP/linear foot (Forand et. al. 2014.), which is for an average planting width of 24 feet. These values were adjusted for the proposed average planting width of 8 feet to results in a reduction of 0.067 lbs of TN/linear foot and 0.023 lbs of TP/linear foot. Shoreline planting projects can be combined with oyster reef breakwater projects or they may be conducted along separate stretches of shoreline.

Table 44: Estimated Vegetative Living Shoreline TN and TP Reductions and Costs

Project	Total Length (feet)	Cost Estimate	TN Reductions (lbs/yr)	Cost/lb/yr of TN Reduction	TP Reductions (lbs/yr)	Cost/lb/yr of TP Reduction
Vegetative living shoreline	105,600	$1,267,200	7,040	$180	2,394	$529

Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

The County conducted a survey of the shorelines, in conjunction with the University of Central Florida, to determine if the shoreline included a bulkhead/seawall, hardened slope/riprap, or no structure to help identify potential locations for future oyster reefs and vegetative living shorelines (**Figure 21**).

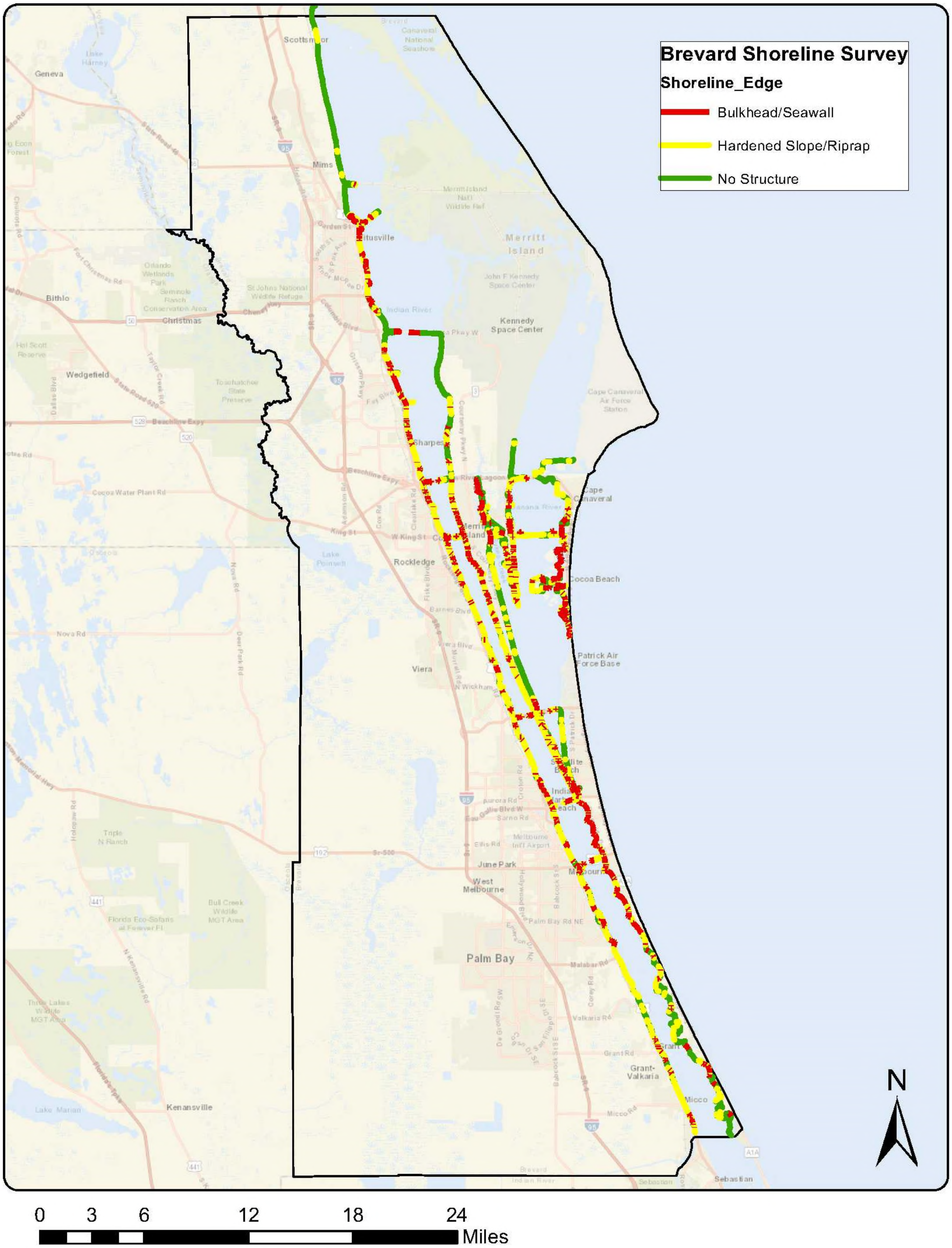
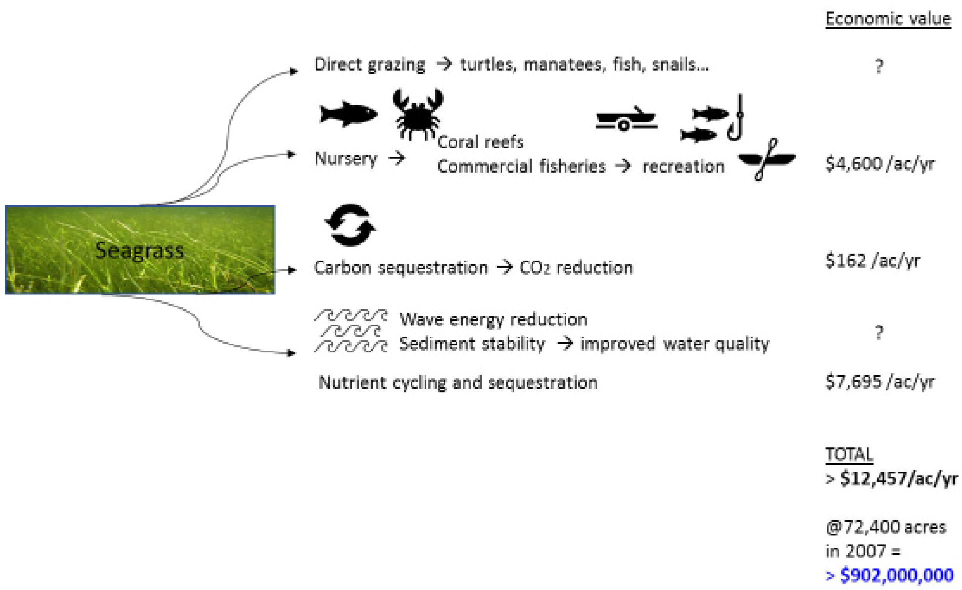


Figure 21: Shoreline Survey to Identify Locations for Oyster Reefs and Living Shorelines

4.3.3 Seagrass Planting (added in 2018)

The original IRL Surface Water Improvement and Management Plan of 1989, as well as subsequent management plans up to and including the current BMAPs, target a healthy, estuarine ecosystem populated by seagrasses. Seagrasses provide crucial benefits to Florida's estuaries by providing food and shelter to a variety of animals, improving water quality, and preventing erosion of sediment. In total, the lagoon's 72,000 acres of seagrass could provide an economic benefit of more than $900 million per year (**Figure 22**, Dewsbury et al. 2016).



Note: Adapted from Dewsbury et al. 2016

Figure 22: Estimated Economic Value of Some Seagrass Services

One key ecological role for seagrasses is to absorb and cycle nitrogen and phosphorus. Seagrasses do not remove these nutrients permanently, but they compete for them against phytoplankton and macroalgae and hold them longer. By stabilizing the cycling of nutrients, seagrasses can increase a system's ability to absorb nutrient loads without the initiation of detrimental blooms of phytoplankton or macroalgae. The contribution of seagrasses can be evaluated by examining the quantity of nutrients bound in its aboveground and belowground structures (its mass of biological material or biomass), with this approach treating uptake and release of nutrients as offsetting components of the nutrient cycle (**Table 45**).

Table 45: Average Nutrients in Seagrass from 1996-2009

Sub-Lagoon	Acres	Seagrass (lbs/100 acres)	Nitrogen (lbs/100 acres)	Phosphorus (lbs/100 acres)
Southern Mosquito Lagoon	14,000	45,000	1,000	100
Banana River Lagoon	21,000	45,000	1,000	100
North IRL	19,000	37,000	900	90
Central IRL	7,000	36,000	900	90

Seagrass restoration may be necessary because more than 30,000 acres of seagrasses were shaded to the point of loss during the superbloom in 2011, recovery has been limited, and the brown tide in 2016 exacerbated the situation. In fact, the Banana River Lagoon in Brevard County experienced the largest initial losses of seagrass. Beyond the reduction in light arising from repeated, intense phytoplankton blooms, the absence of seagrasses has made the sediments less stable, which will hamper future colonization and spread. After the loss of seagrass, nitrogen and phosphorus became available to phytoplankton, drift algae, and other primary producers (**Table 47**). In summary, seagrasses may need some help to recover in the short-term, with more rapid recovery helping to stabilize nutrient cycling in the IRL and reducing the amount of nutrients available to phytoplankton. Measures that could help seagrasses recover could include protecting existing seagrass to promote expansion or protecting areas from waves to reduce the movement of sediment and allow seagrasses to colonize. Planting *Halodule wrightii* would be the initial focus because planting may accelerate recovery, as *Halodule wrightii* is the most common species in the lagoon (Dawes et al. 1995), and this species is a successful pioneer due to its relatively rapid growth and tolerance of varying conditions.

Table 46: Table 46 from the Original Plan is Now Table 66

Note: Table 46 from the original Save Our Indian River Lagoon Project Plan is specifically named in the Save Our Indian River Lagoon Trust Fund Ordinance. Therefore, this table number is being reserved. The updated version of Table 46 from the original plan can be found in **Table 66** of this update.

Table 47: Average Seagrass Lost and Nutrients Made Available to Other Primary Producers in 2015

Sub-Lagoon	Reduction in Acres	Seagrass Reduction* (lbs/100 acres)	Nitrogen Reduction (lbs/100 acres)	Phosphorus Reduction (lbs/100 acres)
Southern Mosquito Lagoon	0	15,000	300	30
Banana River Lagoon	12,000	37,000	900	90
North IRL	1,000	8,000	200	20
Central IRL	4,000	20,000	500	50

* Changes in seagrass cover yield changes in biomass of seagrass within the same number of acres.

Planting seagrass is not a trivial undertaking; it requires considerable planning, resources, and time. For example, having suitable conditions is critical as shown in Tampa Bay where stakeholders invested more than $500 million in projects to reduce nutrient pollution before they saw any return from planting seagrass (Lewis et al. 1999). Costs documented during a workshop on seagrass restoration ranged upward of $1.4 million per acre for larger scale projects (Treat and Lewis 2006). Some of the lessons learned from past projects are selecting sites that will support seagrass growth, employing optimal methods for planting (e.g., type of planting units, use of chemicals to enhance growth, and density of initial planting), and protecting newly planted seagrass from disturbance (e.g., grazing, waves, exposure, and low salinity) until it is established. These factors must be tailored to a specific location; therefore, one or more robust pilot studies are needed prior to attempting full-scale seagrass restoration in the IRL. A proposed two-year pilot study would evaluate 10 acres of seagrass using three planting techniques with the goal of sequestering 80 lbs/yr of TN and 8 lbs/yr of TP. The costs for this pilot study are summarized in **Table 48**, and the three planting techniques that would be evaluated are shown in **Figure 23**.

Similar or more complex pilot studies could be designed to investigate other key components of successful restoration. Overall, the success of planting of seagrass at the scale of tens of thousands of acres will benefit from strategic investment in optimizing techniques.

Appendix E includes additional details about seagrass.

Table 48: Costs for Pilot Study to Evaluate Seagrass Planting Techniques

Task	Quantity	Unit Cost	Total Cost
Design and permit	1	$50,000	$50,000
Install linear feet of breakwater	100	$550	$55,000
Deploy planting units			
Technique 1: Jeb units	30,000	$4	$120,000
Technique 2: Peat pots	1,940	$5	$9,700
Technique 3: Safe pots	2,420	$9	$21,780
Herbivore excluders	220	$369	$81,180
Install herbivore excluders	1	$37,000	$37,000
Remove herbivore excluders	220	$44	$9,680
Maintain sites and enhance sediment monthly	24	$14,080	$337,920
Monitor quarterly	8	$1,000	$8,000
Final report	1	$3,000	$3,000
Total	***N/A***	***N/A***	***$733,260***

Jeb unit: Approximately 3–5 shoots with their rhizomes in a biodegradable pellet filled with a growth medium, installed by hand or planted mechanically. Encapsulated rhizomes resist uprooting. Can be produced in large quantities relatively quickly, and transported easily.

Peat pot: Approximately 25 shoots rooted in a 4-inch pot. The relatively large pot and well-rooted shoots yield protection from uprooting due to grazing or loss due to moving sediment. The units take more time to grow and plant.

Safe pot: Approximately 25 shoots wrapped in a 3-inch, coconut coir pot. The unit provides protection from grazing pressure and sediment transport.

Figure 23: Types of Seagrass Planting Units for Pilot Study

4.4. Respond

The funding raised from the Save Our Indian River Lagoon sales tax will go towards the projects listed in the sections above that will reduce or remove pollutants and restore the lagoon. In addition, $10 million of the funding, over a period of 10 years, will go towards monitoring efforts to measure the success, nutrient removal efficiency, and cost effectiveness of projects included in this plan or in future updates of this plan. Measuring effectiveness is important for reporting progress toward total load reduction targets and for refining project designs to be more effective with each iteration. The monitoring data will be used to determine which projects are providing the most benefit in the most cost-effective manner so that the plan can be updated, as needed. The data will also be used to ensure the lagoon is responding as anticipated to the reductions made so that changes to the plan can be implemented if the lagoon is not responding as expected.

4.4.1 Adaptive Management to Report, Reassess, and Respond

The IRL is located along the Space Coast, which is also known as a global center for exploration, innovation, and development of cutting edge technology. With a dedicated funding source and a brilliant community dedicated to meeting the challenges of today and tomorrow, it is wise to have a process that allows this plan to be updated and revised as new opportunities and better solutions are developed. The intent of the proposed adaptive management strategy is to provide a process that not only allows but also fosters the development and implementation of better tools and techniques, and allows the tax rate to be reduced accordingly or retired ahead of schedule.

Although this plan was developed with the best information available in 2016, identifying the sources of water quality pollution and pairing those problems with the most timely and cost-effective solutions is a rapidly changing field of knowledge. In order to respond to change and take advantage of future opportunities, monitoring is necessary. Even without change in the industry, monitoring will provide data to support and refine the application of existing technology. An adaptive management approach will be used to provide a mechanism to make adjustments to the plan based on new information. As projects from this plan are implemented, the actual costs and nutrient reduction benefits will be tracked and the plan will be modified, as needed, as project performance in the lagoon basin is better understood.

This plan will be updated approximately annually with information from implemented projects and adjustments to the remaining projects. A volunteer committee of diversely skilled citizens will be assembled to assist the County with the annual plan updates. The Citizen Oversight Committee will consist of seven representatives and seven alternates that represent the following fields of expertise: science, technology, economics/finance, real estate, education/outreach, tourism, and lagoon advocacy. The League of Cities will nominate representatives for three fields of expertise and nominate alternates for the remaining four fields of expertise. The Brevard County Board of County Commissioners will nominate representatives for the other four fields of expertise and alternates for the remaining three fields of expertise. All Citizen Oversight Committee representatives and alternates will be appointed by the Brevard County Board of County Commissioners. Appointees will serve for a two-year term, after which time they may be considered for reappointment or replacement. The Committee's recommendations for plan updates will be presented at least annually to the Board of County Commissioners, and changes to the plan will be approved by the Board of County Commissioners.

Brevard County staff will provide project monitoring reports to the Citizen Oversight Committee and will work with them to recommend adjusting the planned projects, as needed. The adaptive management process allows for alternative projects to be submitted by municipalities and other community partners to be reviewed by the Citizen Oversight Committee for inclusion in the next annual update to this plan. Projects that deliver comparable nutrient removal benefits may be approved for inclusion in the plan. If a new approved project costs more than the average cost per pound of TN for that project type listed in this plan at the time of project submittal, the requesting partner must provide the balance of the costs. The requesting partner will be allowed reasonable overhead cost to manage the project from design and permitting through construction completion.

4.4.2 Research Needs

Although this project plan does not fund research, it should be recognized that many important research questions need attention. Universities, state agencies, and non-profit organizations are currently leading lagoon research efforts. This plan acknowledges the research needs identified in the FDEP BMAPs, SJRWMD 2011 Superbloom Report, and IRL National Estuary Program

(NEP) Comprehensive Conservation and Management Plan (CCMP) Update, which are summarized below.

- Research needs identified in the BMAPs (FDEP 2013a, FDEP 2013b, and FDEP 2013c):
  - Collect new bathymetry data for the IRL Basin, which would be used in the seagrass depth limit evaluations.
  - Continue and increase the frequency of the monitoring along the existing seagrass transects to track seagrass composition, density, and extent.
  - Implement phytoplankton, drift algae, and macroalgae monitoring in the basin.
  - Track watershed loads by monitoring inflow and outflow nutrient concentrations for each jurisdiction.
  - Verify the BMP effectiveness values used in the BMAPs, as needed.
  - Test/verify the TN, TP, and seagrass depth regression equations using the seagrass data collected since 1999.
  - Collect groundwater load contribution data and conduct groundwater modeling.
  - Implement storm event monitoring at the major outfalls.
  - Assess potential impacts to seagrass from sediment resuspension due to high boat traffic in parts of the lagoon.
  - Collect data on nutrient flux/internal recycling of legacy nutrient loads held within the IRL sediments and exchanged with the water column.

- Research needs identified in 2011 Superbloom Report (SJRWMD 2016b):
  - Garner an improved understanding of the ideal biological and physiological conditions and tolerances of picocyanobacteria (small cyanobacteria) and Pedinophyceae (green microflagellate), including their ability to use organic forms of nutrients, their ability to fix nitrogen, their nutrient uptake rates, their reproductive rates, and their defenses against grazers.
  - Maintain or expand water quality sampling to ensure spatiotemporal variations are captured adequately, which could include continuous monitoring of various parameters to fill gaps between monthly samples.
  - Develop an improved understanding of the physiological tolerances of drift algae and seagrasses, especially manmade conditions that could be mitigated to improve health or natural resilience.
  - Maintain or expand surveys of drift algae and seagrasses to improve the capacity to evaluate their role in nutrient cycles.
  - Improve the ability to model bottom-up influences from external and internal nutrient loads, including atmospheric deposition, surface water runoff, groundwater inputs, diffusive flux from muck, decomposition of drift algae, and cycling and transformation of nitrogen and phosphorus.
  - Enhance surveys of bacterioplankton to improve the understanding of nutrient cycling.
  - Improve surveys of potential zooplanktonic, infaunal, epifaunal, and fish grazers to enhance the understanding of spatiotemporal variation in top-down control of phytoplankton blooms.
  - Evaluate grazing pressure exerted by common species to enhance the understanding of top-down control of phytoplankton blooms.

- Research needs identified in the CCMP Update (IRL NEP 2008):
  - Undertake further studies of septic systems in the region to quantify the impacts of septic systems on the IRL and to further quantify the extent of “problem” and “potential problem” areas.

- o Continue projects related to monitoring the resources of the IRL and address gaps in data as needed.
- o Identify, inventory and assess finfish and shellfish habitats within the IRL and implement appropriate management and restoration strategies.
- o Develop a coordinated fisheries research agenda to improve the present knowledge of the fisheries in the IRL.
- o Support and expand research initiatives and coordinated finfish and shellfish management strategies specific to the IRL.
- o Support the inventory and assessment of non-native invasive fauna and flora within the IRL basin.
- o Implement a lagoon-wide, multi-species, multi-disciplinary approach to determine the status of emerging infectious diseases in the IRL, assess trends, and identify underlying causes.
- o Undertake studies of wildlife diseases occurring in the IRL region, which may be caused by human activities.
- o Track state, national and international actions and research concerning climate change issues that affect the IRL.
- o Support IRL-based research that considers and integrates global climate change issues and seeks practical scientific, technological and public policy solutions.
- o Undertake research to develop new and improved wetland management BMPs.
- o Monitor boating impacts to IRL natural resources. Where appropriate, establish resource protection zones and monitor their effectiveness.

Section 5. 2017 Plan Update

Local municipalities and partners were invited to submit new projects for inclusion in the Save Our Indian River Lagoon Project Plan. The projects submitted were required to deliver comparable nutrient removal benefits at similar costs as those projects listed in the original plan for each sub-lagoon. To determine the amount of funding that a project would be eligible to receive from the Save Our Indian River Lagoon Trust Fund, the estimated TN reductions from the project were multiplied by the allowable cost/lb/yr of TN shown below in **Table 49** for that project type. The costs shown in **Table 49** are an average of the cost per pound of TN removed from the projects listed in the original plan.

The requesting partners each submitted a "Save Our Indian River Lagoon Project Plan Project Submittal Request Form" to Brevard County for review of the proposed projects. The project forms were provided to the Citizen Oversight Committee to evaluate the potential for inclusion in the plan. The projects recommended by the Citizen Oversight Committee were presented to the Brevard County Board of County Commissioners for approval to include in this plan supplement.

Table 49: Cost Share per Pound of TN Removed by Project Type for the 2017 Plan Supplement

Project Type	Average Cost/lb/yr of TN
WWTF Upgrades for Reclaimed Water	$214
Septic System Removal	$852
Septic System Upgrades	$802
Stormwater Projects	$88
Muck Removal	$408
Oyster Reef/Living Shorelines	$473

5.1. New Projects in the 2017 Plan Supplement

The approved projects for inclusion in the 2017 Save Our Indian River Lagoon Supplement are summarized in **Table 50**. This table lists the responsible entity, project description, sub-lagoon location, TN and TP reductions, and the amount of Save Our Indian River Lagoon Trust Fund funding that is being applied to each project.

Of the 42 projects approved for funding, 13 were later withdrawn by the project applicants. Projects were withdrawn for a variety of reasons including adverse site conditions and insufficient matching funds. Withdrawn projects are noted with an asterisks (*) and are further discussed in **Section 6.4**. Funding from the Save Our Indian River Lagoon Trust Fund that were not used by the withdrawn projects are available to restore funding to the most cost-effective or shovel-ready approved projects of the same type currently in the unfunded projects list (**Table 51**).

Table 50: Summary of New Projects Added in the 2017 Save Our Indian River Lagoon Project Plan Supplement

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Breeze Swept Septic to Sewer Connection	City of Rockledge	Breeze Swept is a neighborhood that consists of 143 single family lots that were constructed between 1958 and 1967. The City of Rockledge has undertaken the process of converting the entire neighborhood from septic to sewer. All of the major infrastructure has been installed and the sewer pipe has been stubbed out to each lot. The next phase will be to abandon the septic tanks and hook up to sewer. Most homes have two tanks that need to be abandoned. While the contractor has been laying the sewer lines, it has been evident that the septic tanks have been failing.	North IRL	2,002	N/A	$880,530
Merritt Island Septic Phase Out Project	Merritt Island Redevelopment Agency	This project consists of three phases: (1) septic phase out in the area of South Tropical Trail, (2) sanitary sewer construction along Cone Road, and (3) septic phase out in the Cone Road Industrial Park. This project proposes to connect approximately 80 properties to a central sewer system. In the Phase 1 area, there are approximately 20 properties that remain on septic systems and are experiencing financial difficulties in paying for the construction and connection costs associated with the hook up to the existing public sanitary sewer system. Many of these remaining properties contain commercial and/or multi-family apartments that require multiple hook ups and higher impact fees. Phase 2 includes the design and construction of the roadway improvements that allow for the installation of the sanitary sewer gravity system and stormwater treatment. Phase 3 consists of the connection of approximately 60 heavy commercial and industrial parcels to the newly constructed public sewer system. A large majority of the existing septic systems were constructed between 1950 and 1985, and the property owners will experience financial hardships relating to the cost of hook up. The funding will assist with the impact fees associated with hook up.	North IRL	2,501	N/A	$320,000

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Micco Sewer Line Extension	Sebastian Inlet Marina	Connecting 34 businesses and homes to sewer.	Central IRL	1,633	N/A	$1,391,316
Hoag Sewer Conversion	City of Melbourne	Installation of 4" forcemain to allow for 7 existing homes and potential 5 others to tie into municipal sewer and either come off existing septic tanks or, once lots are built, never install septic tanks.	Central IRL	101	N/A	$86,031
Penwood Sewer Conversion	City of Melbourne	Installation of 4" forcemain to allow for 4 existing homes and 8 potential homes to tie into municipal sewer and either come off existing septic tanks or, once lots are built, never install septic tanks.	Central IRL	48	N/A	$40,632
Long Point Park Upgrade	Brevard County Parks Department	This will be a denitrification wall to remove nitrogen from the groundwater flowing from the Long Point campground rapid infiltration wet pond to the IRL. An 18"-24" denitrification wall will be constructed around the outside perimeter fence of the existing system.	Central IRL	127	N/A	$101,854
Cocoa Palms LID	City of Cape Canaveral	Exfiltration with treatment train.	Banana	13	10	$1,144
Carver Cove Swale	City of Cape Canaveral	Dry retention with treatment train.	Banana	32	9	$2,816
Holman Road Baffle Box*	City of Cape Canaveral	Upgrade first generation boxes to 2nd generation baffle boxes.	Banana	71	2	$6,248
Center Street Baffle Box*	City of Cape Canaveral	Upgrade first generation boxes to 2nd generation baffle boxes.	Banana	297	9	$26,136
International Drive Baffle Box*	City of Cape Canaveral	Upgrade first generation boxes to 2nd generation baffle boxes.	Banana	443	4	$34,700
Angel Isles Baffle Box*	City of Cape Canaveral	Upgrade first generation boxes to 2nd generation baffle boxes.	Banana	131	3	$11,528
Central Blvd Baffle Box	City of Cape Canaveral	Upgrade first generation boxes to 2nd generation baffle boxes.	Banana	481	14	$34,700
Church Street Type II Baffle Box	City of Cocoa	Retrofitting the Church Street discharge point with a Type 2 Nutrient Separating Baffle Box will be the third component of a complete neighborhood restoration and water quality project. The Church Street outfall currently discharges untreated, urban stormwater from a total area of approximately 73 acres.	North IRL	237	29	$20,856

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Bayfront Stormwater Project	City of Palm Bay	The project will construct wet detention pond to provide treatment and attenuation of stormwater runoff from U.S. 1 (a State roadway) and a 311-acre watershed. The project is a component of the treatment train for the watershed with existing wet detention and check dam conveyance channel constructed upstream. The project will reduce detrimental effects of untreated stormwater on the IRL seagrasses. The land has been purchased and the site is located 1,063 feet from the waters of Palm Bay and 2,077 feet from the convergence with the IRL. This project provides for the retrofit of 311 acres in added retention treatment. Currently the basin flows untreated into the IRL.	Central IRL	348	83	$30,624
Gleason Park Reuse	City of Indian Harbour Beach	Gleason Park is a central recreational feature and includes a large wet detention pond that treats the runoff from 128.9 acres. The City initiated an effort to reuse the stormwater from this wet pond in 2014 and installed three systems with the ability of drawing 58,200 gallons per week. The proposed project will expand the reuse potential of Gleason Park by adding two additional systems and rerouting the water to the south and southwestern portions of the surrounding park. This project should double the current capacity of the reuse in the park and draw an additional 9.29 ac-ft per year. This project would remove an additional 4.53% of TN and TP loading from several large stormwater basins.	Banana	48	9	$4,224
Denitrification Retrofit of Johns Rd Pond	Brevard County	Retrofit of existing stormwater pond bleed-down to flow through denitrification media.	Banana	1,199	N/A	$105,512
St. Teresa Basin Treatment	City of Titusville	Stormwater treatment in the St. Teresa basin before discharging to the IRL.	North IRL	3,100	459	$272,800

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
South Street Basin Treatment	City of Titusville	This project includes the installation of three 2nd generation baffle boxes fitted with nutrient reducing media within the 235-acre South St. basin prior to the IRL outfall. Three boxes within this basin are needed due to the high flow along the main pipe line. By installing these boxes within sections prior to the main 72" pipe line, the nutrient reducing media will have more contact with the stormwater providing more removal.	North IRL	987	156	$86,856
La Paloma Basin Treatment	City of Titusville	This project includes the installation of an 2nd generation baffle box fitted with nutrient reducing media within a 60' stormwater pipe run at the end of the 488 acre La Paloma basin prior to the IRL outfall.	North IRL	2,367	346	$208,296
Kingsmill-Aurora Phase Two	Brevard County	A traditional stormwater pond on major tributary to Eau Gallie River. The project prevents nutrients and sediment from reaching the lagoon.	North IRL	4,176	814	$367,488
Denitrification Retrofit of Huntington Pond	Brevard County	Retrofit of existing stormwater pond bleed-down to flow through denitrification media.	North IRL	1,190	N/A	$104,720
Denitrification Retrofit of Flounder Creek Pond	Brevard County	Retrofit of existing stormwater pond bleed-down to flow through denitrification media.	North IRL	856	N/A	$75,328
L1 Canal Bank Stabilization*	Brevard County	Repair and stabilize channel banks to prevent further bank erosion with associated sediment and nutrient load.	North IRL	995	383	$87,560
Norwood Baffle Box Retrofit*	City of Palm Bay	The project will retrofit or replace two existing baffle box structures for the existing drainage canal serving approximately 507 acres, improving treatment of the drainage basin by enhancing the treatment train with these structures. The structures will improve nutrient removal process from entering the Melbourne Tillman Canal C-1, which leads to Turkey Creek and IRL.	Central IRL	1,631	254	$143,528
Victoria Pond*	City of Palm Bay	The project will install a baffle box structure for the existing drainage canal serving approximately 122 acres, improving treatment of the drainage basin by enhancing the treatment train with this structure. The structures will improve nutrient removal process from entering the IRL.	Central IRL	267	42	$23,486

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Goode Park*	City of Palm Bay	The project will retrofit or replace the existing outfall weir structure for the existing basin drainage which drains two drainage ponds serving approximately 254 acres, improving treatment of the drainage basin by enhancing the treatment train with this structure. The structures will improve nutrient removal upstream of Turkey Creek and IRL.	Central IRL	794	121	$69,872
Florin Pond*	City of Palm Bay	The project will retrofit or replace the existing outfall structure for the existing drainage pond serving approximately 18.28 acres, improving treatment of the drainage basin by enhancing the treatment train with this structure. The structure will improve nutrient removal upstream of Turkey Creek and IRL.	Central IRL	75	11	$6,600
Cherie Down Park Swale*	City of Cape Canaveral	Construction of swale system with Bold & Gold ® media filter.	Banana	27	9	$2,376
Cape Shores Swales	City of Cape Canaveral	Construction of swale system with Bold & Gold ® media filter.	Banana	31	15	$2,746
Justamere Rd Swale	City of Cape Canaveral	Construction of swale system with Bold & Gold ® media filter.	Banana	6	3	$528
Hitching Post Berms	City of Cape Canaveral	Construction of a berm/swale system with Bold & Gold ® filter media.	Banana	29	22	$2,552
Cliff Creek Baffle Box	City of Melbourne	Installation of a 2nd generation baffle box with BAM.	North IRL	3,952	797	$347,781
Thrush Drive Baffle Box	City of Melbourne	Installation of a 2nd generation baffle box with BAM.	North IRL	3,661	773	$322,200
Airport Boulevard Dry Retrofit*	City of Melbourne	Installation of Bold and Gold ® under an existing dry retention pond.	North IRL	99	23	$8,718
Nasa Boulevard Pond Retrofit*	City of Melbourne	Installation of Bold and Gold ® under an existing dry retention pond.	Central IRL	1,097	157	$96,532
General Aviation Drive Retrofit*	City of Melbourne	Installation of Bold and Gold ® under an existing dry retention swale.	Central IRL	158	10	$13,937
Stewart Road Dry Retrofit	City of Melbourne	Installation of Bold and Gold ® under an existing dry retention swale.	Central IRL	208	47	$18,344
Mims Muck Removal: Outflow Water Nutrient Removal	Brevard County	The treatment of muck dredging spoil site out-flow water for the removal of nitrogen and phosphorus.	North IRL	2,803	244	$400,000

Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Grand Canal Muck Dredging	Brevard County	Dredging and outflow nutrient reduction of approximately 605,000 cy of muck sediments from an area of 97 acres within the Grand Canal system.	North IRL	27,802	2,447	$10,000,000
Sykes Creek Muck Dredging	Brevard County	Dredging and outflow water nutrient reduction of approximately 660,000 cy of muck sediments from an area of 187 acres within Sykes Creek.	Banana	30,693	2,722	$10,000,000
Turkey Creek Shoreline Restoration	City of Palm Bay	Construct a living shoreline of 1,200 linear feet.	Central IRL	240	82	$113,500
Total	**-**	**-**	**-**	***96,956***	***10,109***	***$25,874,599***

* Projects withdrawn as part of 2018 Update. See **Section 6.4**.

5.2. Unfunded Projects in the 2017 Plan Supplement

In order to include the new projects approved as part of the 2017 Supplement, the funding had to be shifted from the least cost-effective or shovel-ready projects of the same or similar type that were listed in the original plan. This balance is shown in **Figure 24**. The projects listed in **Table 51** were unfunded in the 2017 annual update process. However, if additional funding is obtained from other sources, such as grants or legislative appropriations, these projects could be added back to the plan tables through a streamlined approval process. Since these projects were previously approved for inclusion in the Save Our Indian River Lagoon Project Plan, if additional funds become available during the fiscal year, individual projects in **Table 3** could be funded with Trust Fund dollars, if their reinsertion is recommended by the Citizen Oversight Committee and if a budget change request for such projects is approved by the Board of County Commissioners. This accelerated process would not need to wait for the next annual plan update. Reinsertion of these projects into the funded Save Our Indian River Lagoon Project Plan would be reflected retroactively in the next annual update to the plan.

Table 51: Summary of Unfunded Projects from the 2017 Save Our Indian River Lagoon Project Plan Supplement

Sub-lagoon	Project Name	Cost	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
North IRL	Sykes Creek C septic system removal	$1,700,000	1,426	N/A
Central IRL	112 septic system upgrades	$1,792,000	2,233	N/A
Banana River Lagoon	Stormwater project in Basin 754	$100,000	734	95
Banana River Lagoon	Stormwater project in Basin 602	$100,000	1,068	109
North IRL	Stormwater project in Basin 1434	$125,000.00	932	112
North IRL	Stormwater project in Basin 1151	$125,000.00	1,057	141
North IRL	Stormwater project in Basin 1078	$125,000.00	1,250	187
North IRL	Stormwater project in Basin 1399	$125,000.00	1,570	256
North IRL	Stormwater project in Basin 1301	$125,000.00	1,025	154
North IRL	Stormwater project in Basin 1368	$125,000.00	1,311	200
North IRL	Stormwater project in Basin 408	$125,000.00	1,179	170
North IRL	Stormwater project in Basin 338	$125,000.00	1,902	188
North IRL	Stormwater project in Basin 1367	$100,000.00	1,042	146
North IRL	Stormwater project in Basin 1384	$100,000.00	923	142
North IRL	Stormwater project in Basin 1318	$100,000.00	1,124	148
North IRL	Stormwater project in Basin 155	$100,000.00	1,149	122
North IRL	Stormwater project in Basin 289	$100,000.00	1,112	223
North IRL	Stormwater project in Basin 193	$100,000.00	1,316	198
North IRL	Stormwater project in Basin 1441	$100,000.00	1,034	149
North IRL	Stormwater project in Basin 660	$100,000.00	844	212
North IRL	Stormwater project in Basin 952	$100,000.00	1,251	212
Banana River Lagoon	29% Sykes Creek dredging	$7,000,000	12,536	1,112
Banana River Lagoon	38% Cape Canaveral Area dredging	$10,000,000	33,051	5,026
North IRL	29% Grand Canal dredging	$7,000,000	11,356	1,000
North IRL	38% Eau Gallie dredging	$10,000,000	33,512	5,023
Total	***Total***	***$39,592,000***	***115,937***	***15,325***

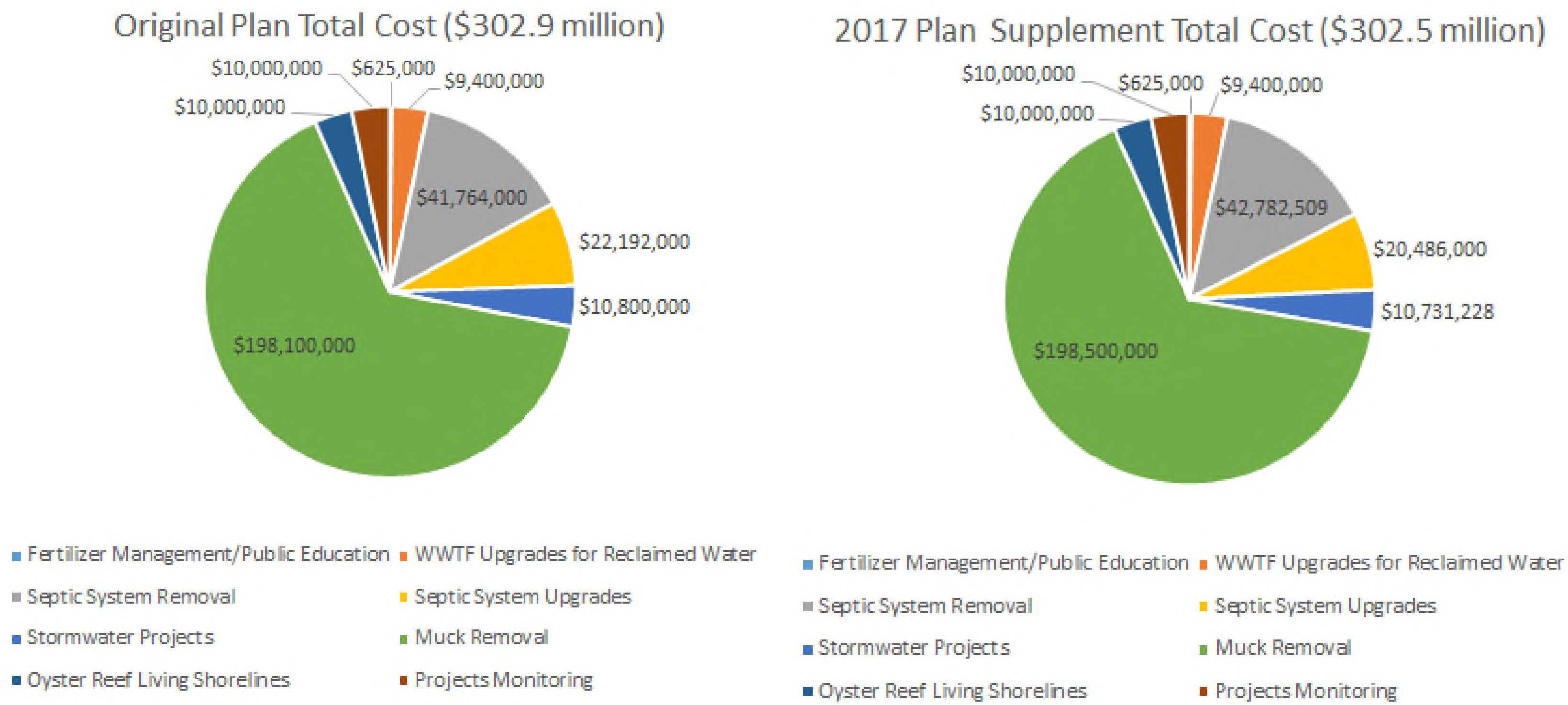


Figure 24: Comparison of the Original Plan Cost by Project Category (Left) versus the 2017 Plan Supplement Cost by Project Category (Right)

Section 6. 2018 Plan Update

For the 2018 Plan Update, local municipalities and partners were once again invited to submit new projects for inclusion in the Save Our Indian River Lagoon Project Plan. The projects submitted were required to deliver comparable nutrient removal benefits at similar costs as those projects listed in the original plan for each sub-lagoon.

To determine the amount of funding that a project would be eligible to receive from the Save Our Indian River Lagoon Trust Fund, the estimated TN reductions from the project were multiplied by the allowable cost/lb/yr of TN shown below in **Table 52** for that project type. The costs shown in **Table 52** are an average of the cost per pound of TN removed from the projects listed in the SOIRLPP, as amended. Based on a recommendation from the Citizen Oversight Committee, instead of having one allowable cost/lb/yr of TN for stormwater projects, as was the case for the 2017 Plan Supplement, there are now three allowable costs based on the project location. Separate allowable costs are now provided for septic system removal by sewer extension (expanding the sanitary sewer collection system to connect septic systems) and by sewer connection (connecting septic systems to existing sanitary sewer collection system infrastructure). Cost-share for a new project, muck interstitial water treatment, was also added. In addition, based on new information about the reductions associated with oyster reefs versus vegetative living shoreline, separate allowable costs are included for each of these types of living shorelines.

The requesting partners each submitted a “Save Our Indian River Lagoon Project Plan Project Submittal Request Form” to Brevard County for review of the proposed projects. The project forms were provided to the Citizen Oversight Committee to evaluate the potential for inclusion in the plan. The projects recommended by the Citizen Oversight Committee were presented to the Brevard County Board of County Commissioners for approval to include in this plan update.

Table 52: Cost Share per Pound of TN Removed by Project Type for the 2018 Plan Update

Project Type	Average Cost/lb/yr of TN
WWTF Upgrades for Reclaimed Water	$231
Septic System Removal by Sewer Extension	$872
Septic System Removal by Sewer Connection	$443
Septic System Upgrades	$802
Stormwater Projects	-
Mainland	$88
Merritt Island	$89
Barrier Island	$99
Muck Removal	$403
Treatment of Muck Interstitial Water	$175
Oyster Reef	$392
Vegetative Living Shorelines	$180

6.1. Additional Project Benefits

Although the eligible Save Our Indian River Lagoon Trust Fund contribution to new projects is determined based on the amount of TN removed, the benefits of implementing these projects include reductions in other pollutant sources, as well. These projects will reduce a multitude of different contaminates to meet water quality targets and improve the health, productivity, aesthetic appeal, and economic value of the lagoon. These additional benefits vary according to project design and site-specific conditions but often include significant reduction of pathogenic bacteria, viruses, human and animal wastes, chemicals, metals, plastics, and sediments (see **Table 53**).

Table 53: Pollutants Removed by Different Project Types

Stormwater	Septic System Removal	Septic System Upgrade	Muck Removal
Nitrogen Phosphorus Sediments Escherichia coli (E. coli) Viruses Fecal coliform Pesticides Metals Oil Litter	Nitrogen Phosphorus E. coli Viruses Fecal coliform Pharmaceuticals Biochemical Oxygen Demand (BOD)	Nitrogen Phosphorus E. coli Viruses Fecal coliform BOD	Nitrogen Phosphorus Clay sediments Hydrogen sulfide BOD

This Save Our Indian River Lagoon Project Plan is an adaptable document informed by science and under supervision of the community. As monitoring updates our understanding of IRL pollutants, the plan projects will target funds to the most successful and cost-effective projects.

6.2. Project Funding

6.2.1 Revenue Projection Update

The County calculated a new estimate for Save Our Indian River Lagoon Sales Tax revenues based on the median of collections in the first 12 months of the sales tax with the current consumer price index for inflation of 2.13% compounded over the life of the tax. The new estimate for the period of 2017 through 2026 is $486,392,368.53, or on average $48.6 million per year. This current estimate is $14.6 million per year more than the $34 million per year estimate in the original Save Our Indian River Lagoon Plan, which was based on 2016 dollars. This new estimate allows for the implementation of additional projects each year.

6.2.2 Contingency Fund Reserve

A Contingency Fund Reserve will be included with the development and adoption of the County's budget each fiscal year, and will amount to 5% of the total Trust Fund dollars that are budgeted for all approved projects scheduled to occur or move ahead in that fiscal year. This includes projects in the Save Our Indian River Lagoon Project Plan, including additions captured in annual updates or Plan Supplements. The purpose of the reserve is to fund emergency response to harmful algal blooms and major fish kills or to cover reasonable funding shortfalls that may occur during project implementation and would delay implementation or completion of that project unless a ready source of funds is on hand.

If the cost increase for an individual project is less than 10% of the estimated cost or eligible amount of Trust Fund cost-share stated in the Save Our Indian River Lagoon Project Plan or update, then additional funding from the contingency reserve may be allocated to the project, as needed, in accordance with Brevard County policies and administrative orders. For projects that are contracted with municipalities or other partners and encounter cost overruns, the cost-share agreement may be increased up to 10% over the eligible cost-share amount stated in Attachment E of the cost-share contract. This amendment will be executed by the Chairman of the County Commission and the appropriate municipal representative or authorized agent of a partnering organization.

For project cost increases that are more than 10% above the estimated cost or eligible amount of Trust Fund cost-share stated in the Save Our Indian River Lagoon Project Plan or update, County staff will evaluate the project circumstances and present findings and a recommendation to the Citizen Oversight Committee. The Committee will make a recommendation to the County Manager or County Commission (based on respective signature authority adopted in County contracting policy) on whether the project should proceed.

6.3. New Projects in the 2018 Plan Update

The approved projects for inclusion in the 2018 Plan Update are summarized in **Table 54**. This table lists the responsible entity, project description, sub-lagoon location, TN and TP reductions, and the amount of Save Our Indian River Lagoon Trust Fund funding that is being applied to each project. Once the 2018 Plan Update is approved by the County Commission, the projects are part of the Save Our Indian River Lagoon Project Plan, and are reflected in the updated plan tables shown in **Section 7**.

New project types added as part of this 2018 Update include:

- Expanded public education and outreach to address grass clippings, excess irrigation, stormwater pond maintenance, and septic system maintenance.
- Sewer laterals rehabilitation.
- Treatment of muck interstitial water.
- Refinement of benefits for oyster reefs versus vegetated living shorelines.

Table 54: Summary of New Projects for the Save Our Indian River Lagoon Plan 2018 Update

Plan Year	Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
1-10	Expanded Outreach	Brevard County	See details in **Section 4.1.1**.	All	105,165	TBD	$1,100,000
2	Grant Street WRF Nutrient Removal Improvements	City of Melbourne	Biological nutrient removal processes added at WRF by replacing the trickling filter and oxidation ditch with biological nutrient removal process with anoxic/aerobic tankage.	Central IRL	25,627	9,671	$5,919,837
2	Sylvan Estates Septic-to-Sewer Conversion	City of West Melbourne	Connection of 59 residences (currently on septic) to new sewer extension.	Central IRL	1,073	N/A	$935,656
1	Riverside Drive Septic-to-Sewer Conversion	City of Melbourne	Installation of forcemain to tie into an existing manhole. Each home would be required to install a small grinder pump system and then connect to the City's forcemain.	North IRL	305	N/A	$265,960
2	Roxy Avenue Septic-to-Sewer Conversion	City of Melbourne	Installation of forcemain to tie into an existing manhole. Each home would be required to install a small grinder pump system and then connect to the City's forcemain.	North IRL	102	N/A	$88,944
1	Sewer Lateral Repair/ Replacement	Brevard County	See details in **Section 4.1.3**.	All	TBD	TBD	$840,000
2	Stormwater LID Convair Cove 1 – Blakey Blvd	City of Cocoa Beach	Stormwater-low impact development treatment train consisting of high infiltration PaveDrain permeable pavers flowing to a native plant bioswale along a residential road discharging to the Banana River Lagoon. There is currently no treatment for stormwater in this basin, developed in the late 1950s. System reduces runoff volume (thereby reducing pollutants) as stormwater flows downstream over a high infiltration paver system, which then flows to the native landscape bioswale. The bioswale will use native grasses and oak tree canopy to provide additional runoff and pollutant reduction through vegetative nutrient uptake. Design will evaluate whether biosorption activated media (BAM) will improve efficiency of this treatment train system. Monitoring will be evaluated as a means of determining actual built TN and TP removal of system. Adjacent neighborhood park provides an excellent opportunity for public education and outreach.	Banana	30	3	$2,922

Plan Year	Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
2	Stormwater LID Convair Cove 2- Dempsey Drive	City of Cocoa Beach	Stormwater-low impact development treatment train consisting of high infiltration PaveDrain permeable pavers flowing to a native plant bioswale along a residential road discharging to the Banana River Lagoon. There is currently no treatment for stormwater in this basin, developed in the late 1950s. System reduces runoff volume (thereby reducing pollutants) as stormwater flows downstream over a high infiltration paver system, which then flows to the native landscape bioswale. The bioswale will use native grasses and oak tree canopy to provide additional runoff and pollutant reduction through vegetative nutrient uptake. Design will evaluate whether biosorption activated media (BAM) will improve efficiency of this treatment train system. Monitoring will be evaluated as a means of determining actual built TN and TP removal of system. Adjacent neighborhood park provides an excellent opportunity for public education and outreach.	Banana	29	3	$2,842
1	Big Muddy @ Cynthia Baffle Box	City of Indian Harbour Beach	Nutrient separating baffle box with media filter, currently proposed to be NSBB-8-14+UFF (with Bold & Gold media).	Banana	269	248	$26,637
2	Grant Place Baffle Box	City of Melbourne	Installation of 2nd generation baffle box with Bold & Gold.	Central IRL	937	193	$82,481
2	Crane Creek/M-1 Canal Flow Restoration	St. Johns River Water Management District	Treat and restore flows from an approximately 5,300-acre watershed, which was diverted from the Upper St. Johns River Basin (USJRB) to the IRL when the M-1 Canal was constructed in the early 20th century. Work will include construction of an operable water control structure in the M-1 Canal near Evans Road, a pump station and pipeline near I-95, and a stormwater treatment area west of I-95, to remove nutrients prior to discharge to the USJRB.	Central IRL	23,113	2,719	$2,033,944
2	Apollo/GA Baffle Box	City of Melbourne	Installation of 2nd generation baffle box with Bold & Gold within the existing ditch line that runs parallel to Apollo Boulevard near General Aviation Drive.	North IRL	3,381	479	$297,522
1	Cocoa Beach Muck Dredging – Phase III	City of Cocoa Beach	Dredge muck from 13 residential canals (39 acres of muck).	Banana	2,435	366	$981,305
1	Cocoa Beach Muck Dredging – Phase III Interstitial	City of Cocoa Beach	Scrub nutrients from the return water associated with dredging 13 canal areas in the City of Cocoa Beach, which have extensive muck accumulated and are impacting the Banana River Lagoon's water quality. The sites include all canals that are directly connected to the Banana River Lagoon. Survey of muck area and depths has been completed and a permit has been approved by USACE/FDEP for the muck dredging.	Banana	2,942	TBD	$514,809
1	Merritt Island Muck Removal – Phase 1	Brevard County	The removal of accumulated muck from 30 canals on central Merritt Island.	Banana	4,805	722	$1,936,415

Plan Year	Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
1	Muck Removal of Indian Harbour Beach Canals	City of Indian Harbour Beach	Dredge muck from 12 canal areas (36 acres of muck).	Banana	2,257	339	$909,571
1	Muck Interstitial Water Treatment for Indian Harbour Beach Canals	City of Indian Harbour Beach	Scrub nutrients from the return water associated with dredging 12 canal areas in the City of Indian Harbour Beach, which have extensive muck accumulated and are impacting the Banana River Lagoon's water quality. The sites include all canals that are directly connected to the Banana River Lagoon, including all the Grand Canal located within the City. Survey of muck area and depths has been completed and permitting is ongoing.	Banana	27,418	TBD	$4,798,197
1	Muck Re-dredging in Turkey Creek	Brevard County	Dredge 11 acres of Turkey Creek where muck was re-deposited after Hurricane Irma.	Central	981	147	$215,000
1	Muck Interstitial Water Treatment for Turkey Creek	Brevard County	Scrub nutrients from the return water associated with the re-dredging of Turkey Creek.	Central	N/A	688	N/A
1	Eden Isles Lane Oyster Living Shoreline	Brevard Zoo	Three adjacent properties on Eden Isles Lane on Merritt Island have some mangroves in place and a low sloping, sandy shoreline. The water depth 10 feet from shore is shallow, so the design may need to be modified somewhat to obtain the same reduction benefits to the water quality. The project will construct a 245-foot oyster reef along the three properties. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Banana	49	17	$21,805
1	Marina Isles Oyster Living Shoreline	Brevard Zoo	The gated community of Marina Isles is in Indian Harbour Beach. The property manager is interested in adding an oyster reef to the existing mangrove shoreline. The water depth 10 feet from shore varies from about 1-2 feet. The project will construct 300 feet of oyster reef on this property. The reef will be constructed using a proven design research and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Banana	60	20	$26,700
1	Bettinger Oyster Living Shoreline	Brevard Zoo	The Bettingers own property on Bali Road in Cocoa Beach. There is a seawall on the property and the project would construct an oyster reef of 120 feet in front of the seawall. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Banana	24	8	$10,680

Plan Year	Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
1	Cocoa Beach Country Club Plants Living Shoreline	Marine Resources Council	Planting three-year-old mangroves on 5-foot centers along western lagoon shoreline with Spartina in two rows. Additional native plants will be added, as needed, to fill in areas.	Banana	67	23	$16,014
1	Lagoon House Shoreline Restoration Planting	Marine Resources Council	Planting three-year-old mangroves on 5-foot centers along western lagoon shoreline with Spartina in two rows. Additional native plants will be added, as needed, to fill in areas.	Central IRL	100	34	$23,961
1	McNabb Park Oyster Living Shoreline	City of Cocoa Beach	Construct 360 feet of living shoreline comprised of oyster shell bags. Location is on an arterial waterway at the end of a residential canal in the North Thousand Islands. This will be a pilot project to test the suitability for oyster restoration in this portion of the lagoon. McNabb Park is a neighborhood park/playground that will provide an opportunity for a public education kiosk on living shorelines and stormwater management.	Banana	72	24	$34,056
1	McNabb Park Plants Living Shoreline	City of Cocoa Beach	Construct 360 feet of living shoreline comprised of red mangrove and Spartina. Location is on an arterial waterway at the end of a residential canal in the North Thousand Islands. McNabb Park is a neighborhood park/playground that will provide an opportunity for a public education kiosk on living shorelines and stormwater management.	Banana	24	8	$5,760
1	Gitlin Oyster Living Shoreline	Brevard Zoo	Ms. Gitlin owns canal property on Cinnamon Court. There is a seawall with a water depth of about 3 feet. The project would construct an oyster reef of 180 feet in front of the seawall. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Banana	36	12	$16,020
1	Coconut Point/EELS Oyster Living Shoreline	Brevard Zoo	The EELS properties at Coconut Point Sanctuary, Hog Point Cove Sanctuary, and Maritime Hammock Sanctuary all have shorelines that are good candidates for an oyster reef. The project would be three phases and to construct an oyster reef in a total of 5,425 feet. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Central IRL	1,085	369	$509,950

Plan Year	Project Name	Responsible Entity	Project Description	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
1	Wexford Oyster Living Shoreline	Brevard Zoo	Wexford is a gated community located in Melbourne Beach. The property has a seawall with a water depth of about one to two feet. The project would construct an oyster reef of 350 feet in front of the seawall. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	Central IRL	70	24	$31,150
1	Riverview Park Oyster Living Shoreline	City of Melbourne	Retrofitting approximately 1,150 linear feet of existing shoreline by means of a living shoreline oyster reef.	Central IRL	230	78	$108,790
1	Riverview Park Plants Living Shoreline	City of Melbourne	Retrofitting approximately 1,150 linear feet of existing shoreline by means of a vegetated living shoreline.	Central IRL	77	26	$18,480
1	Bomalaski Oyster Living Shoreline	Brevard Zoo	Ms. Bomalaski owns property on Dragon Point Drive on Merritt Island. The property has a steep shoreline made up of coquina riprap. The water depth at 10 feet from the shoreline is about 3 feet. The project will construct a 100-foot oyster reef. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	North IRL	20	7	$8,900
1	Oliver Oyster Living Shoreline	Brevard Zoo	The Olivers, Swanns, and Hermanson own property on Swann Grove Lane on Merritt Island. All three want an oyster reef built along their shorelines on their three adjacent properties. The shoreline is made up mostly of coquina riprap and has a depth of about one foot at 10 feet from the shoreline. The project will build 580 feet of oyster reef on these adjoining properties. The reef will be constructed using a proven design researched and tested by Florida Tech's IRL Research Institute. The design uses both blank shell bags and spat on shell bags, which provide a structure for free-swimming oyster larvae to attach.	North IRL	116	39	$51,620
	Total	***-***	***-***	***-***	***202,899***	***16,267***	***$21,475,928***

6.4. Project Changes

6.4.1 Withdrawals

Some of the projects submitted by the local governments as part of the 2017 Plan Supplement were determined to not be cost-effective and/or feasible to implement after further investigation. Therefore, the local governments requested that these projects be removed from the Save Our Indian River Lagoon Project Plan so that the funding could be used for other projects. **Table 55** lists the projects that have been removed from the plan at the request of the responsible entity.

Table 55: Summary of Year 0 and Year 1 Project Withdrawals

Project Name	Responsible Entity	Sub-Lagoon	TN Reduction (lbs/yr)	TP Reduction (lbs/yr)	Plan Funding
Holman Road Baffle Box	City of Cape Canaveral	Banana	71	2	$6,248
Center Street Baffle Box	City of Cape Canaveral	Banana	297	9	$26,136
International Drive Baffle Box	City of Cape Canaveral	Banana	443	4	$34,700
Angel Isles Baffle Box	City of Cape Canaveral	Banana	131	3	$11,528
Cherie Down Park Swale	City of Cape Canaveral	Banana	27	9	$2,376
Norwood Baffle Box Retrofit	City of Palm Bay	Central IRL	1,631	254	$143,528
Victoria Pond	City of Palm Bay	Central IRL	267	42	$23,486
Goode Park	City of Palm Bay	Central IRL	794	121	$69,872
Florin Pond	City of Palm Bay	Central IRL	75	11	$6,600
Airport Boulevard Dry Retrofit	City of Melbourne	North IRL	99	23	$8,718
Nasa Boulevard Pond Retrofit	City of Melbourne	Central IRL	1,097	157	$96,532
General Aviation Drive Retrofit	City of Melbourne	Central IRL	158	10	$13,937
L-1 Canal Bank Stabilization	Brevard County	North IRL	995	383	$87,560
Total	**-**	**-**	***6,085***	***1,028***	***$531,221***

In addition, Brevard County reviewed the basins proposed for stormwater treatment in the original plan and identified those basins that should be removed because they could not be easily treated or are basins where the County already has projects. These basins are summarized in **Table 56**.

Table 56: Summary of Stormwater Basin Withdrawals

Sub-lagoon	Project Name	Cost	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Banana	Stormwater project in Basin 979	$225,000	3,275	448
Banana	Stormwater project in Basin 1280	$175,000	1,735	236
Banana	Stormwater project in Basin 1317	$125,000	1,679	290
Banana	Stormwater project in Basin 1063	$100,000	1,235	192
Banana	Stormwater project in Basin 970	$100,000	1,092	185
Banana	Stormwater project in Basin 995	$100,000	1,048	169
Banana	Stormwater project in Basin 998	$100,000	1,196	189
Banana	Stormwater project in Basin 1309	$100,000	1,016	152
Banana	Stormwater project in Basin 754	$100,000	734	95
Banana	Stormwater project in Basin 602	$100,000	1,068	109
North IRL	Stormwater project in Basin 1430	$175,000	2,255	335
North IRL	Stormwater project in Basin 327	$125,000	1,999	283
Central IRL	Stormwater project in Basin 1582	$200,000	2,402	443
Total	**-**	***$1,725,000***	***20,734***	***3,126***

6.4.2 Revisions

The Brevard County Long Point Park project was completed in Year 0 instead of Year 1. This project constructed a denitrification wall to remove nitrogen from the groundwater flowing from the Long Point campground rapid infiltration wet pond to the IRL. The City of Melbourne Stewart Road dry retention swale retrofit project was incorrectly shown in the 2017 Plan Supplement as located in the Central IRL, and the location has been corrected to the North IRL as part of this 2018 Plan Update. The Brevard County Denitrification Retrofit of Johns Road Pond was incorrectly shown in the 2017 Plan Supplement as located in the Banana River Lagoon, and the location has been corrected to the North IRL as part of this 2018 Plan Update. In addition, the Brevard County Grand Canal muck dredging project was incorrectly shown in the 2017 Plan Supplement as located in the North IRL, and the location has been corrected to the Banana River Lagoon as part of this 2018 Plan Update.

All of the unfunded projects from the 2017 Plan Supplement were added back to the plan, except for Banana River Lagoon stormwater projects in basins 754 and 602 (withdrawn as noted above), as part of this 2018 Plan Update. A portion of both the Sykes Creek dredging project and Grand Canal dredging project in Banana River Lagoon were unfunded in the 2017 Plan Supplement. The funding restored as part of this plan update was revised based on updated cost estimates that include treatment of the muck interstitial water (**Table 57**).

In addition, the Turkey Creek muck removal project required dredging as a result of impacts caused by Hurricane Irma in September 2017. The County is pursuing Federal Emergency Management Agency (FEMA) reimbursement for this project where state and federal disaster recovery funding would cover 87.5% of the total cost of additional dredging and the interstitial water treatment and the Save Our Indian River Lagoon Tax Fund would cover the remaining 12.5% of the costs (see **Table 54**).

Table 57: Updates to Sykes Creek and Grand Canal Dredging Projects

Category	Sykes Creek			Grand Canal		
	Cost	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)	Cost	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Muck Removal	$4,705,428	11,676	1,754	$2,440,971	6,057	910
Treatment of Interstitial Water	$11,248,704	64,278	N/A	$15,579,397	89,025	N/A
Total	***$15,954,132***	***75,954***	***1,754***	***$18,020,368***	***95,082***	***910***

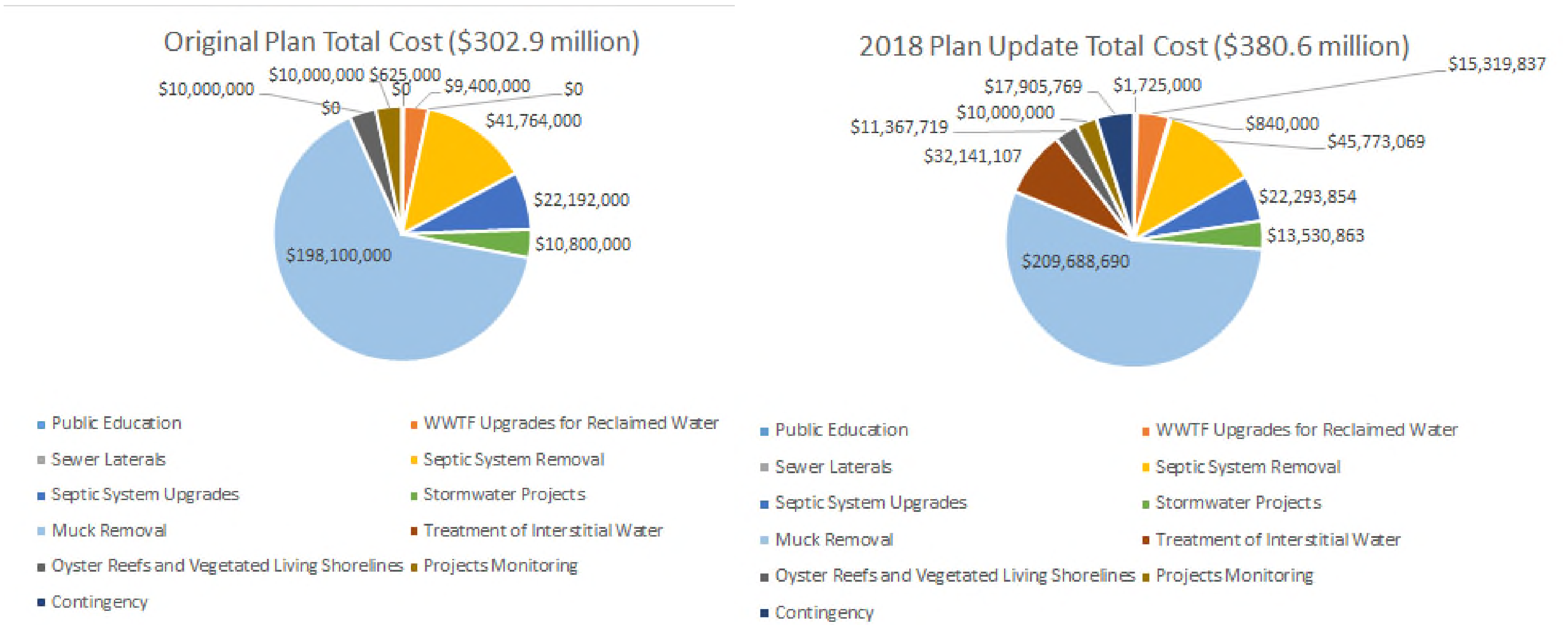


Figure 25: Comparison of the Original Plan Cost by Project Category (Left) versus the 2018 Plan Update Cost by Project Category (Right)

Section 7. Summary of the Plan through the 2018 Update

The County has been working with its municipalities, FDOT District 5, and Patrick AFB to update total loading estimates to the lagoon and revise the TMDLs for nitrogen and phosphorus using the best available data and more detailed modeling than previously available. Based on this process, five-month TMDLs, which target the load reductions needed during the seagrass growing period (January – May), were proposed in addition to annual TMDLs that protect water quality year-round. These load reductions specifically target water quality conditions needed for restoring lagoon seagrass beds to provide crucial habitat for fish and other marine life. Therefore, as this Save Our Indian River Lagoon Project Plan was developed, the TN and TP reductions from the project types that **Reduce** incoming load were compared to the five-month TMDLs for each sub-lagoon. After satisfying the five-month TMDLs, annual load reductions for each project were compared to the 12-month TMDLs. In all cases, the projects identified to meet the five-month TMDLs were sufficient to meet the 12-month TMDLs. As projects are implemented, progress toward meeting the five-month and full-year TMDLs will be tracked.

Figure 25 shows the distribution of funding in the original plan versus the 2018 update for each type of project that reduces incoming loading. The majority of funds dedicated to reducing incoming load are directed at projects that improve the treatment of human waste (**Figure 26**). These projects include several types such as greater treatment of reclaimed water, upgrade of septic systems onsite, conversion from septic to sewer when feasible, and repair of leaky sewer laterals.

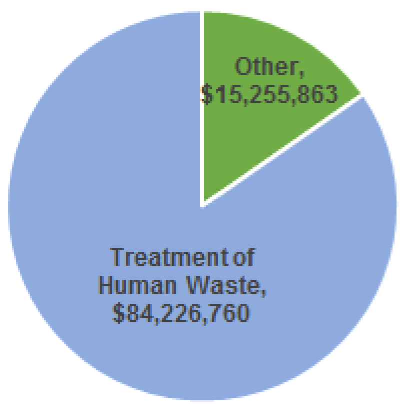


Figure 26: Funding for Reduce Projects

Only the projects that reduce external loading to the lagoon, not muck removal or living shorelines, were used to meet the TMDLs. Even though decades of treatment projects to reduce nutrient loads have been completed to date, only the reductions associated with BMAP projects that were completed between January 1, 2010 (the last year of the SWIL model period) and February 29, 2016 (the end of the last BMAP reporting period when the Save Our Indian River Lagoon Project Plan was developed) were included in the load reduction calculations as these projects also provide nutrient load reductions that have occurred after the period of record used to develop the proposed TMDL updates. In Zone A of the Central IRL, the reductions from SJRWMD's C-1 re-diversion project, which was implemented with cost-share funding from FDEP and Brevard County, were also included as this project results in significant load reductions. As shown in **Table 58**, **Table 60**, and **Table 62**, the projects proposed in this plan plus the recently completed BMAP projects and C-1 re-diversion project exceed the five-month reductions called for by the proposed TMDL updates.

The total project reductions were also compared to the full year estimated loading to the lagoon from the SWIL model. As shown in **Table 59**, **Table 61**, and **Table 63**, the proposed projects in this plan, as well as the recently completed BMAP projects and C-1 re-diversion project, achieve significant reductions of the overall loading to the lagoon and exceed the full year reductions called for by the proposed TMDL updates.

Table 58: Banana River Lagoon Project Reductions to Meet Five-Month TMDL

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	2,945	603
Future Education	2,262	155
Sewer Laterals	412	78
Septic System Removal	5,723	0
Septic System Upgrade	2,144	0
Stormwater Projects	14,701	2,153
BMAP Projects (2010-February 2016)	5,303	1,440
Total	***33,490***	***4,429***
TMDL Reductions (five-month)	***30,337***	***2,737***
% of TMDL Reductions Achieved	***110.4%***	***161.8%***

Table 59: Banana River Lagoon Project Reductions Compared to Full Year Loading

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	7,068	1,446
Future Education	5,429	372
Sewer Laterals	988	188
Septic System Removal	13,736	0
Septic System Upgrade	5,145	0
Stormwater Projects	35,282	5,168
BMAP Projects (2010-February 2016)	12,726	3,456
Total	***80,374***	***10,630***
Starting Load (full year)	***477,020***	***44,269***
% of Starting Load Reduced	***16.8%***	***24.0%***
Full-Year TMDL % Reductions	***9.0%***	***9.6%***

Table 60: North IRL Project Reductions to Meet Five-Month TMDL

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	8,070	1,651
Future Education	6,199	424
WWTF Upgrade for Reclaimed Water	5,987	TBD
Septic System Removal	7,891	0
Septic System Upgrade	4,279	0
Stormwater Projects	30,832	4,548
BMAP Projects (2010-February 2016)	16,983	3,180
Total	***80,241***	***9,803***
TMDL Reductions (five-month)	***61,447***	***7,410***
% of TMDL Reductions Achieved	***130.6%***	***132.3%***

Table 61: North IRL Project Reductions Compared to Full Year Loading

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	19,368	3,962
Future Education	14,877	1,018
WWTF Upgrade for Reclaimed Water	14,368	TBD
Septic System Removal	18,939	0
Septic System Upgrade	10,270	0
Stormwater Projects	73,996	10,914
BMAP Projects (2010-February 2016)	40,758	7,632
Total	***192,576***	***23,526***
Starting Load (full year)	***988,847***	***99,340***
% of Starting Load Reduced	***19.5%***	***23.7%***
Full-Year TMDL % Reductions	***11.4%***	***11.4%***

Table 62: Central IRL Project Reductions to Meet Five-Month TMDL

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	8,108	1,659
Future Education	6,228	426
WWTF Upgrade for Reclaimed Water	15,311	TBD
Septic System Removal	13,166	0
Septic System Upgrade	5,155	0
Stormwater Projects	14,044	1,803
C-1 Re-Diversion	53,892	6,295
BMAP Projects (2010-February 2016)	378	243
Total	***116,282***	***10,426***
TMDL Reductions (five-month)*	***67,547***	***8,151***
% of TMDL Reductions Achieved	***172.1%***	***127.9%***

* The TMDL reductions are for Zone A only; however, some of the septic system projects are in Zone SEB. There are sufficient projects to achieve the Zone A reductions without the Zone SEB projects (refer to **Section 2.1**).

Table 63: Central IRL Project Reductions Compared to Full Year Loading

Project	TN Reductions (lbs/yr)	TP Reductions (lbs/yr)
Fertilizer Ordinance Implementation	19,460	3,981
Future Education	14,947	1,023
WWTF Upgrade for Reclaimed Water	36,746	TBD
Septic System Removal	31,599	0
Septic System Upgrade	12,371	0
Stormwater Projects	33,705	4,326
C-1 Re-Diversion	129,341	15,108
BMAP Projects (2010-February 2016)	908	582
Total	***279,077***	***25,020***
Starting Load (full year)*	***698,937***	***95,051***
% of Starting Load Reduced	***39.9%***	***26.3%***
Full-Year TMDL % Reductions	***22.9%***	***21.5%***

* The TMDL reductions are for Zone A only; however, some of the septic system are in Zone SEB. There are sufficient projects to achieve the Zone A reductions without the Zone SEB projects (refer to **Section 2.1**).

In addition to the projects that address the external nutrient loading summarized above, the plan includes muck removal, oyster reefs, and vegetated living shoreline projects that will significantly reduce internal nutrient loading within the lagoon itself. The reductions from these projects are summarized in **Table 64**, along with the percentage of nutrients from muck flux that would be reduced by these projects.

Table 64: Muck Removal, Oyster Reef, and Living Shoreline Project Reductions Compared to Nutrient Loadings from Muck Flux

Project Type	Mosquito Lagoon		Banana River Lagoon		North IRL		Central A	
	TN (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)
Muck Removal Project Reductions	35,000	5,250	287,545	43,197	147,913	22,220	11,033	1,754
Oyster Reefs	N/A	N/A	10,672	342	10,921	315	3,398	521
Vegetated Living Shorelines	N/A	N/A	2,993	1,027	3,056	1,050	1,185	406
Total Project Reductions	35,000	5,250	301,210	44,566	161,890	23,585	15,616	2,681
Estimated Muck Flux Loading	97,400	14,600	705,561	106,771	478,824	71,824	42,500	6,250
% of Muck Flux Reduced	***35.9%***	***36.0%***	***42.7%***	***41.7%***	***33.8%***	***32.8%***	***36.7%***	***42.9%***

Table 65 summarizes all the project types, as well as their estimated costs, TN and TP reductions, and costs per pound of TN and TP removed. The information from this table on the project reductions and cost effectiveness was used to determine the schedule for implementing the projects (see **Table 66**). Projects that could achieve large reductions quickly, such as fertilizer reductions and WWTF upgrades, as well as the most cost-effective septic to sewer, and stormwater projects were prioritized for earliest implementation. This prioritization allows for the reductions to occur as quickly as possible while best using available funding sources. Project scheduling also considered the timing of upstream reductions with downstream removals, where feasible.

The timeline in **Table 66** is shown in years after funding from the Save Our Indian River Lagoon sales tax became available. Each year corresponds to the County's fiscal year, which is October 1st through September 30th. Year 1 started on October 1, 2017, which was just before revenues would have begun to accrue if the funding source had been a property tax, as initially considered. When the referendum approved by the voters was a sales tax, collections began in January 2017 and the first revenue check was received by the County in March 2017. Therefore, a plan update was adopted in March 2017 to begin plan implementation in Year 0. **Table 66a** includes the cost estimates based on 2016 dollars, which were used to develop the plan. **Table 66b** includes the original cost estimates with inflation starting in Year 2 of the plan. The construction index of 3.25% was used for the inflation value.

As noted in **Section 4.4.1**, an adaptive management approach will be used in the implementation of this plan. As projects are completed and information on the actual construction costs, timeline, and reductions are obtained, the plan will be adjusted, as needed, to ensure that the most cost-effective projects are being used to meet the IRL restoration goals.

Table 65: Summary of Projects, Estimated TN and TP Reductions, and Costs

Project	Estimated Total Project Cost	TN Reductions (lbs/yr)	Cost/lb/yr of TN	TP Reductions (lbs/yr)	Cost/lb/yr of TP
Public Education	$1,725,000	35,253	$49	2,413	$715
WWTF Upgrades for Reclaimed Water	-	-	-	-	-
City of Titusville Osprey WWTF	$8,000,000	14,368	$557	TBD	TBD
City of Palm Bay WRF	$1,400,000	11,119	$126	TBD	TBD
City of Melbourne WRF	$5,919,837	25,627	$231	9,671	$612
Sewer Laterals	-	-	-	-	-
Satellite Beach Pilot Project	$840,000	988	$850	188	$4,468
Septic System Removal by Sewer Extension	-	-	-	-	-
Banana River Lagoon Septic System Connections	$12,260,000	13,736	$893	N/A	N/A
North IRL Septic System Connections	$14,375,434	18,939	$759	N/A	N/A
Central IRL Septic System Connections	$11,373,635	14,069	$808	N/A	N/A
Septic System Removal by Sewer Connection	-	-	-	-	-
Central IRL Septic System Connections	$7,764,000	17,530	$443	N/A	N/A
Septic System Upgrades	-	-	-	-	-
Banana River Lagoon Septic System Upgrades	$4,128,000	5,145	$802	N/A	N/A
North IRL Septic System Upgrades	$8,240,000	10,270	$802	N/A	N/A
Central IRL Septic System Upgrades	$9,925,854	12,371	$802	N/A	N/A
Stormwater Projects	-	-	-	-	-
Banana River Lagoon Stormwater Projects	$3,481,111	35,282	$99	5,168	$674
North IRL Stormwater Projects	$6,777,703	73,996	$92	10,914	$621
Central IRL Stormwater Projects	$3,272,049	33,705	$97	4,326	$756
Muck Removal	-	-	-	-	-
Mosquito Lagoon Muck Removal	$16,100,000	35,000	$460	5,250	$3,067
Banana River Lagoon Muck Removal	$122,973,690	287,545	$428	43,197	$2,847
North IRL Muck Removal	$64,750,000	147,913	$438	22,220	$2,914
Central IRL Muck Removal	$5,465,000	11,033	$495	1,657	$3,298

Project	Estimated Total Project Cost	TN Reductions (lbs/yr)	Cost/lb/yr of TN	TP Reductions (lbs/yr)	Cost/lb/yr of TP
Treatment of Interstitial Water	-	-	-	-	-
Banana River Lagoon Interstitial Water	$32,141,107	183,663	$175	TBD	TBD
North IRL Interstitial Water	$400,000	2,803	$143	244	$1,639
Oyster Reefs	-	-	-	-	-
Banana River Lagoon	$4,225,138	10,672	$396	342	$12,354
North IRL	$4,316,092	10,921	$395	315	$13,702
Central IRL	$1,444,030	3,398	$425	521	$2,772
Vegetative Living Shorelines	-	-	-	-	-
Banana River Lagoon	$541,482	2,993	$181	1,027	$527
North IRL	$547,489	3,056	$179	1,050	$521
Central IRL	$293,488	1,185	$248	406	$723
Projects Monitoring	$10,000,000	-	-	-	-
Contingency	$17,905,769	-	-	-	-
Total	***$380,585,908***	***1,022,580***	***$372 (average)***	***108,909***	***$3,495 (average)***

Table 66a: Timeline for Funding Needs (Table 46 in the Original Save Our Indian River Lagoon Project Plan)

Project Name	Total Project Cost	Cost by Year										
		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Public Education	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer Management	$625,000	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$125,000	$50,000	$50,000	$50,000	$50,000	$100,000	$50,000	$50,000	$50,000	$50,000
Grass Clippings	$200,000	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Excess Irrigation	$300,000	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
Stormwater Pond Maintenance	$300,000	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
Septic System Maintenance	$300,000	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
WWTF Upgrades	-	-	-	-	-	-	-	-	-	-	-	-
North IRL	$8,000,000	Titusville Osprey Design & Permitting	Titusville Design & Start Construction	Titusville Complete Construction	-	-	-	-	-	-	-	-
		$300,000	$1,700,000	$6,000,000	-	-	-	-	-	-	-	-
Central IRL	$7,319,837	-	City of Palm Bay Permit & Engineering	City of Palm Bay Construction, City of Melbourne WRF	-	-	-	-	-	-	-	-
		-	$200,000	$7,119,837	-	-	-	-	-	-	-	-
Sewer Laterals	-	-	-	-	-	-	-	-	-	-	-	-
Satellite Beach Pilot	$840,000	-	Pilot Project	-	-	-	-	-	-	-	-	-
		-	$840,000	-	-	-	-	-	-	-	-	-
Septic Removal	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$12,260,000	Sykes M & Sykes T Engineering	Sykes Creek N	Sykes Creek M	Sykes Creek T	Sykes Creek X	Sykes Creek V	Sykes Creek U	Sykes Creek Z	-	-	-
		$500,000	$1,720,000	$910,000	$2,530,000	$280,000	$1,960,000	$2,900,000	$1,460,000	-	-	-
North IRL	$14,375,434	S. Central C Eng., Rockledge Breeze Swept, MIRA	South Central C, Riverside Drive	Cocoa K, Melbourne, Roxy Avenue	Cocoa J, Rockledge, Titusville	S Beaches A	South Central A	South Central D	Sykes Creek C	-	-	-
		$1,650,530	$2,455,960	$1,008,944	$2,540,000	$840,000	$2,300,000	$1,880,000	$1,700,000	-	-	-
Central IRL	$19,137,635	Micco, Hoag, Penwood	Palm Bay B, Sewer Hookups, Sylvan	-	West Melbourne	Palm Bay A	-	-	-	-	-	-
		$1,517,979	$13,399,656	-	$2,240,000	$1,980,000	-	-	-	-	-	-
Septic Upgrades	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$4,128,000	-	24 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades
		-	$384,000	$416,000	$416,000	$416,000	$416,000	$416,000	$416,000	$416,000	$416,000	$416,000
North IRL	$8,240,000	-	35 Upgrades	40 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades
		-	$560,000	$640,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000
Central IRL	$9,925,854	Long Point	44 Upgrades	50 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades
		$101,854	$704,000	$800,000	$1,040,000	$1,040,000	$1,040,000	$1,040,000	$1,040,000	$1,040,000	$1,040,000	$1,040,000
Stormwater Projects	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$3,481,111	3 Cape Canaveral & 1 Indian Harbour	3 Cape Canaveral, 1 Indian Harbour	2 Cocoa Beach, 6 Projects	6 Projects	6 Projects	6 Projects	7 Projects	-	-	-	-
		$42,884	$32,463	$880,764	$625,000	$600,000	$600,000	$700,000	-	-	-	-
North IRL	$6,777,703	1 Cocoa Project	3 Titusville, 4 County, 3 Melbourne	1 Melbourne, 3 Projects	4 Projects	5 Projects	5 Projects	5 Projects	5 Projects	5 Projects	3Projects	-
		$20,856	$1,909,325	$822,522	$650,000	$725,000	$625,000	$625,000	$600,000	$500,000	$300,000	-
Central IRL	$3,272,049	1 Palm Bay	-	1 Melbourne, 1 SJRWMD	1 Project	1 Project	1 Project	1 Project	1 Project	-	-	-
		$30,624	-	$2,116,425	$275,000	$225,000	$225,000	$200,000	$200,000	-	-	-

Project Name	Total Project Cost	Cost by Year										
		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Muck Removal & Interstitial Treatment	-	-	-	-	-	-	-	-	-	-	-	-
Mosquito Lagoon	$16,100,000	-	-	-	-	-	-	-	-	3% Near Haulover Canal	50% Near Haulover Canal	47% Near Haulover Canal
		-	-	-	-	-	-	-	-	$500,000	$8,100,000	$7,500,000
Banana River Lagoon	$155,114,797	-	71% Sykes Creek, Cocoa Beach, Merritt Island, Indian Harbour Beach, 55% Grand Canal	8% of Canals, Mathers Area, 29% Sykes Creek, 20% Grand Canal	Newfound Harbor Area, 25% Grand Canal	8% of Canals	1% Cocoa Beach Area, 62% Cape Canaveral Area	1% Cocoa Beach Area, 8% of Canals, 38% Cape Canaveral	25% Cocoa Beach Area, Pineda Causeway Area	37% Cocoa Beach Area, 8% of Canals	35% Cocoa Beach Area	8% of Canals
		-	$29,140,297	$20,349,500	$12,875,000	$5,250,000	$16,775,000	$15,725,000	$15,312,500	$20,142,500	$14,295,000	$5,250,000
North IRL	$65,150,000	Mims Outflow	16% Eau Gallie Area, 1% Titusville Area	20% Eau Gallie Area, 1% Titusville	19% Eau Gallie Area, 50% Titusville Area	48% Titusville Area, 4% Cocoa Area, 45% Eau Gallie	71% Cocoa Area, 1/2 Rockledge Area, Canals	25% Cocoa Area, 1/2 Rockledge Area	-	-	-	-
		$400,000	$3,840,000	$4,950,000	$15,697,500	$21,572,500	$13,440,000	$5,250,000	-	-	-	-
Central IRL	$5,465,000	-	29% Melbourne Causeway, Turkey Creek	71% Melbourne Causeway	Mullet Creek Area, Canals	-		-	Goat Creek Area	-	Trout Creek Area	-
		-	$415,000	$500,000	$4,200,000	-		-	$175,000	-	$175,000	-
Oyster Reefs	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$4,225,138	-	Eden Isles, Marina Isles, Bettinger, McNabb, Gitlin, Marsh Harbor	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,329 ft Oysters
		-	$156,611	$457,323	$457,323	$457,323	$457,323	$457,323	$457,323	$457,323	$457,323	$409,943
North IRL	$4,316,092	-	Bomalaski, Oliver, Indian River Drive	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	3,093 ft Oysters
		-	$240,450	$472,843	$472,843	$472,843	$472,843	$472,843	$472,843	$472,843	$472,843	$292,898
Central IRL	$1,444,030	-	Coconut Point, Riverview Park, Wexford, Riverview Senior Resort	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	611 ft Oysters
		-	$680,194	$88,247	$88,247	$88,247	$88,247	$88,247	$88,247	$88,247	$88,247	$57,860
Living Shorelines	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$541,482	-	Cocoa Beach, McNabb	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting
		-	$21,774	$57,746	$57,746	$57,746	$57,745	$57,745	$57,745	$57,745	$57,745	$57,745
North IRL	$547,489	-	Indian River Drive	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	3,169 ft Planting
		-	$22,860	$60,825	$60,826	$60,825	$60,825	$60,825	$60,825	$60,825	$60,825	$38,028
Central IRL	$293,488	-	Lagoon House, Riverview Park, Turkey Creek	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting
		-	$155,941	$15,283	$15,283	$15,283	$15,283	$15,283	$15,283	$15,283	$15,283	$15,283
Project Monitoring	$10,000,000	-	Year 1 Monitoring	Year 2 Monitoring	Year 3 Monitoring	Year 4 Monitoring	Year 5 Monitoring	Year 6 Monitoring	Year 7 Monitoring	Year 8 Monitoring	Year 9 Monitoring	Year 10 Monitoring
		-	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Contingency	$17,905,769	-	Year 1 Contingency	Year 2 Contingency	Year 3 Contingency	Year 4 Contingency	Year 5 Contingency	Year 6 Contingency	Year 7 Contingency	Year 8 Contingency	Year 9 Contingency	Year 10 Contingency
		-	$2,997,427	$2,440,563	$2,313,288	$1,805,288	$2,027,913	$1,598,163	$1,204,038	$1,288,788	$1,375,163	$855,138
Total	***$380,585,908***	***$4,564,727***	***$62,945,958***	***$51,251,822***	***$48,579,056***	***$37,911,055***	***$42,586,179***	***$33,561,429***	***$25,284,804***	***$27,064,554***	***$28,878,429***	***$17,957,895***

Table 66b: Timeline for Funding Needs (Table 46 in the Original Save Our Indian River Lagoon Project Plan) with inflation

Project Name	Total Project Cost	Cost by Year										
		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Public Education	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer Management	$713,508	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$125,000	$51,625	$53,303	$55,035	$56,824	$117,341	$60,577	$62,546	$64,579	$66,678
Grass Clippings	$231,935	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$20,000	$20,650	$21,321	$22,014	$22,730	$23,468	$24,231	$25,018	$25,832	$26,671
Excess Irrigation	$339,919	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,813	$26,651	$27,518	$28,412	$29,335	$30,289	$31,273	$32,289	$33,339
Stormwater Pond Maintenance	$339,919	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,813	$26,651	$27,518	$28,412	$29,335	$30,289	$31,273	$32,289	$33,339
Septic System Maintenance	$339,919	-	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program	Year 6 of Program	Year 7 of Program	Year 8 of Program	Year 9 of Program	Year 10 of Program
		-	$75,000	$25,813	$26,651	$27,518	$28,412	$29,335	$30,289	$31,273	$32,289	$33,339
WWTF Upgrades	-	-	-	-	-	-	-	-	-	-	-	-
North IRL	$8,195,000	Titusville Osprey Design & Permitting	Titusville Design & Start Construction	Titusville Complete Construction	-	-	-	-	-	-	-	-
		$300,000	$1,700,000	$6,195,000	-	-	-	-	-	-	-	-
Central IRL	$7,551,232	-	City of Palm Bay Permit & Engineering	City of Palm Bay Construction, City of Melbourne WRF	-	-	-	-	-	-	-	-
		-	$200,000	$7,351,232	-	-	-	-	-	-	-	-
Sewer Laterals	-	-	-	-	-	-	-	-	-	-	-	-
Satellite Beach Pilot	$840,000	-	Pilot Project	-	-	-	-	-	-	-	-	-
		-	$840,000	-	-	-	-	-	-	-	-	-
Septic Removal	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$13,564,139	Sykes M & Sykes T Engineering	Sykes Creek N	Sykes Creek M	Sykes Creek T	Sykes Creek X	Sykes Creek V	Sykes Creek U	Sykes Creek Z	-	-	-
		$500,000	$1,720,000	$939,575	$2,697,122	$308,197	$2,227,493	$3,402,893	$1,768,859	-	-	-
North IRL	$15,660,137	S. Central C Eng., Rockledge Breeze Swept, MIRA	South Central C, Riverside Drive	Cocoa K, Melbourne, Roxy Avenue	Cocoa J, Rockledge, Titusville	S Beaches A	South Central A	South Central D	Sykes Creek C	-	-	-
		$1,650,530	$2,455,960	$1,041,735	$2,707,783	$924,591	$2,613,895	$2,206,013	$2,059,630	-	-	-
Central IRL	$19,484,993	Micco, Hoag, Penwood	Palm Bay B, Sewer Hookups, Sylvan	-	West Melbourne	Palm Bay A	-	-	-	-	-	-
		$1,517,979	$13,399,656	-	$2,387,966	$2,179,392	-	-	-	-	-	-
Septic Upgrades	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$4,792,247	-	24 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades	26 Upgrades
		-	$384,000	$429,520	$443,479	$457,892	$472,774	$488,139	$504,004	$520,384	$537,296	$554,758
North IRL	$9,637,338	-	35 Upgrades	40 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades	55 Upgrades
		-	$560,000	$660,800	$938,130	$968,619	$1,000,099	$1,032,602	$1,066,162	$1,100,812	$1,136,588	$1,173,527
Central IRL	$11,578,672	Long Point	44 Upgrades	50 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades
		$101,854	$704,000	$826,000	$1,108,699	$1,144,731	$1,181,935	$1,220,348	$1,260,009	$1,300,959	$1,343,241	$1,386,896
Stormwater Projects	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$3,814,716	3 Cape Canaveral & 1 Indian Harbour	3 Cape Canaveral, 1 Indian Harbour	2 Cocoa Beach, 6 Projects	6 Projects	6 Projects	6 Projects	7 Projects	-	-	-	-
		$42,884	$32,463	$909,389	$666,285	$660,422	$681,886	$821,388	-	-	-	-
North IRL	$7,453,924	1 Cocoa Project	3 Titusville, 4 County, 3 Melbourne	1 Melbourne, 3 Projects	4 Projects	5 Projects	5 Projects	5 Projects	5 Projects	5 Projects	3Projects	-
		$20,856	$1,909,325	$849,254	$692,937	$798,010	$710,297	$733,382	$726,928	$625,461	$387,473	-
Central IRL	$3,489,355	1 Palm Bay	-	1 Melbourne, 1 SJRWMD	1 Project	1 Project	1 Project	1 Project	1 Project	-	-	-
		$30,624	-	$2,185,209	$293,165	$247,658	$255,707	$234,682	$242,309	-	-	-

Project Name	Total Project Cost	Cost by Year										
		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Muck Removal & Interstitial Treatment	-	-	-	-	-	-	-	-	-	-	-	-
Mosquito Lagoon	$21,088,893	-	-	-	-	-	-	-	-	3% Near Haulover Canal	50% Near Haulover Canal	47% Near Haulover Canal
		-	-	-	-	-	-	-	-	$625,461	$10,461,778	$10,001,654
Banana River Lagoon	$176,384,382	-	71% Sykes Creek, Cocoa Beach, Merritt Island, Indian Harbour Beach, 55% Grand Canal	8% of Canals, Mathers Area, 29% Sykes Creek, 20% Grand Canal	Newfound Harbor Area, 25% Grand Canal	8% of Canals	1% Cocoa Beach Area, 62% Cape Canaveral Area	1% Cocoa Beach Area, 8% of Canals, 38% Cape Canaveral	25% Cocoa Beach Area, Pineda Causeway Area	37% Cocoa Beach Area, 8% of Canals	35% Cocoa Beach Area	8% of Canals
		-	$29,140,297	$21,010,859	$13,725,474	$5,778,691	$19,064,384	$18,451,894	$18,551,818	$25,196,708	$18,463,101	$7,001,157
North IRL	$71,264,856	Mims Outflow	16% Eau Gallie Area, 1% Titusville Area	20% Eau Gallie Area, 1% Titusville	19% Eau Gallie Area, 50% Titusville Area	48% Titusville Area, 4% Cocoa Area, 45% Eau Gallie	71% Cocoa Area, 1/2 Rockledge Area, Canals	25% Cocoa Area, 1/2 Rockledge Area	-	-	-	-
		$400,000	$3,840,000	$5,110,875	$16,734,418	$23,744,917	$15,274,236	$6,160,410	-	-	-	-
Central IRL	$5,846,733	-	29% Melbourne Causeway, Turkey Creek	71% Melbourne Causeway	Mullet Creek Area, Canals	-	-	-	Goat Creek Area	-	Trout Creek Area	-
		-	$415,000	$516,250	$4,477,436	-	-	-	$212,021	-	$226,026	-
Oyster Reefs	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$4,939,564	-	Eden Isles, Marina Isles, Bettinger, McNabb, Gitlin, Marsh Harbor	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,829 ft Oysters	4,329 ft Oysters
		-	$156,611	$472,186	$487,532	$503,377	$519,737	$536,628	$554,068	$572,076	$590,668	$546,681
North IRL	$5,011,082	-	Bomalaski, Oliver, Indian River Drive	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	4,993 ft Oysters	3,093 ft Oysters
		-	$240,450	$488,210	$504,077	$520,460	$537,375	$554,839	$572,872	$591,490	$610,713	$390,595
Central IRL	$1,574,803	-	Coconut Point, Riverview Park, Wexford, Riverview Senior Resort	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	931 ft Oysters	611 ft Oysters
		-	$680,194	$91,115	$94,076	$97,134	$100,291	$103,550	$106,915	$110,390	$113,978	$77,159
Living Shorelines	-	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$633,686	-	Cocoa Beach, McNabb	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting	4,812 ft Planting
		-	$21,774	$59,623	$61,560	$63,561	$65,626	$67,759	$69,961	$72,235	$74,582	$77,006
North IRL	$637,007	-	Indian River Drive	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	5,069 ft Planting	3,169 ft Planting
		-	$22,860	$62,802	$64,844	$66,950	$69,126	$71,373	$73,692	$76,087	$78,560	$50,712
Central IRL	$317,891	-	Lagoon House, Riverview Park, Turkey Creek	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting	1,274 ft Planting
		-	$155,941	$15,780	$16,293	$16,822	$17,369	$17,933	$18,516	$19,118	$19,739	$20,381
Project Monitoring	$11,596,748	-	Year 1 Monitoring	Year 2 Monitoring	Year 3 Monitoring	Year 4 Monitoring	Year 5 Monitoring	Year 6 Monitoring	Year 7 Monitoring	Year 8 Monitoring	Year 9 Monitoring	Year 10 Monitoring
		-	$1,000,000	$1,032,500	$1,066,056	$1,100,703	$1,136,476	$1,173,411	$1,211,547	$1,250,923	$1,291,578	$1,333,554
Contingency	$20,137,893	-	Year 1 Contingency	Year 2 Contingency	Year 3 Contingency	Year 4 Contingency	Year 5 Contingency	Year 6 Contingency	Year 7 Contingency	Year 8 Contingency	Year 9 Contingency	Year 10 Contingency
		-	$2,997,427	$2,519,881	$2,466,096	$1,987,086	$2,304,675	$1,875,303	$1,458,749	$1,612,174	$1,776,130	$1,140,372
Total	***$427,460,490***	***$4,564,727***	***$62,945,958***	***$52,917,506***	***$51,788,007***	***$41,728,815***	***$48,398,168***	***$39,381,364***	***$30,633,735***	***$33,855,661***	***$37,298,731***	***$23,947,819***

Appendix A: Funding Needs and Leveraging Opportunities

Brevard County explored a variety of possible mechanisms to fund the IRL projects in this plan, including:

- Special Taxing District approved by referendum to allow an ad valorem tax levy and bonds
- Special Act by the legislature allowing ad valorem tax levy by referendum to issue bonds
- Local government surtax (½ cent sales tax)
- Altering legislation to allow for Tourist Development Council funding to be used for lagoon restoration
- Municipal Service Taxing Unit/Special District
- Increased stormwater utility assessment

The County placed a referendum on the November 8, 2016 ballot for the ½ cent sales tax, and this referendum passed by more than 60% of the vote. The Save Our Indian River Lagoon ½ cent sales tax will generate approximately $34 million per year. The proposed 1 mill increase would have generated approximately $32 million per year, whereas the proposed increase in ½ mill would have only generated $16 million per year. To implement the projects in a timely manner according to the schedule in **Table 66**, and to accelerate the projects where possible, the County will seek to use funds generated from the sales tax to leverage matching funding from grants and appropriations and/or pay debt service on bonds. If additional funding is provided through matching funds from other sources, additional projects may be implemented, which would increase the overall plan cost, and/or project timelines may be moved up to allow the benefits of those projects to occur earlier than planned.

Examples of other funding programs (many from FDEP 2015) are:

- Section 319 grant program – FDEP administers funds received from USEPA to implement projects or programs that reduce nonpoint sources of pollution. Projects or programs must benefit Florida's impaired waters, and local sponsors must provide at least a 40% match or in-kind contribution. Eligible activities include demonstration and evaluation of urban and agricultural stormwater BMPs, stormwater retrofits, and public education.
- TMDL grants – Funding for projects related to the implementation of TMDLs may be available through periodic legislative appropriations to FDEP. When funds are available, the program prioritizes stormwater retrofit projects to benefit impaired waters, similar to the Section 319 grant program.
- Water management district funding - Florida's five regional water management districts offer financial assistance for a variety of water-related projects, for water supply development, water resource development, and surface water restoration. Assistance may be provided from ad valorem tax revenues or from periodic legislative appropriations for alternative water supply development and Surface Water Improvement and Management projects. The amount of funding available, matching requirements, and types of assistance may vary from year to year.
- IRL NEP – The IRL Council funds projects each year through their work plan process (http://www.irlcouncil.com/irl-council.html).
- Budget Appropriation – The Florida Legislature may solicit applications directly for projects, including water projects, in anticipation of upcoming legislative sessions. This process is

an opportunity to secure legislative sponsorship of project funding through the state budget.

- Clean Water State Revolving Fund (SRF) loan program – This program provides low-interest loans to local governments to plan, design, and build or upgrade wastewater, stormwater, and nonpoint source pollution prevention projects. Discounted assistance for small communities is available. Interest rates on loans are below market rates and vary based on the economic wherewithal of the community. The Clean Water SRF is Florida's largest financial assistance program for water infrastructure.
- Florida Rural Water Association Loan Program – This program provides low-interest bond or bank financing for community utility projects in coordination with FDEP's SRF program. Other financial assistance may also be available.
- Rural Development Rural Utilities Service Guaranteed and Direct Loans and Grants – The U.S. Department of Agriculture's program provides a combination of loans and grants for water, wastewater, and solid waste projects to rural communities and small incorporated municipalities.
- Small Cities Community Development Block Grant Program – The Florida Department of Economic Opportunity makes funds available annually for water and sewer projects that benefit low- and moderate-income persons.
- State Housing Initiatives Partnership Program – Florida Housing administers the program, which provides funds to local governments as an incentive to create partnerships that produce and preserve affordable homeownership and multifamily housing. The program is designed to provide very low, low and moderate income families with assistance. Funding may be used for emergency repairs, new construction, rehabilitation, down payment and closing cost assistance, impact fees, construction and gap financing, mortgage buy-downs, acquisition of property for affordable housing, matching dollars for federal housing grants and programs, and homeownership counseling (http://www.floridahousing.org/HousingPartners/LocalGovernments/).
- Rural Development Funding – The U. S. Department of Agriculture provides funds that will cover the repair and maintenance of private septic systems. The amount of funds available, as well as the specific purposes for which grants are intended, changes from year to year. Additional details are posted on the Department of Agriculture's website (http://www.rurdev.usda.gov/Home.html).

Appendix B: References

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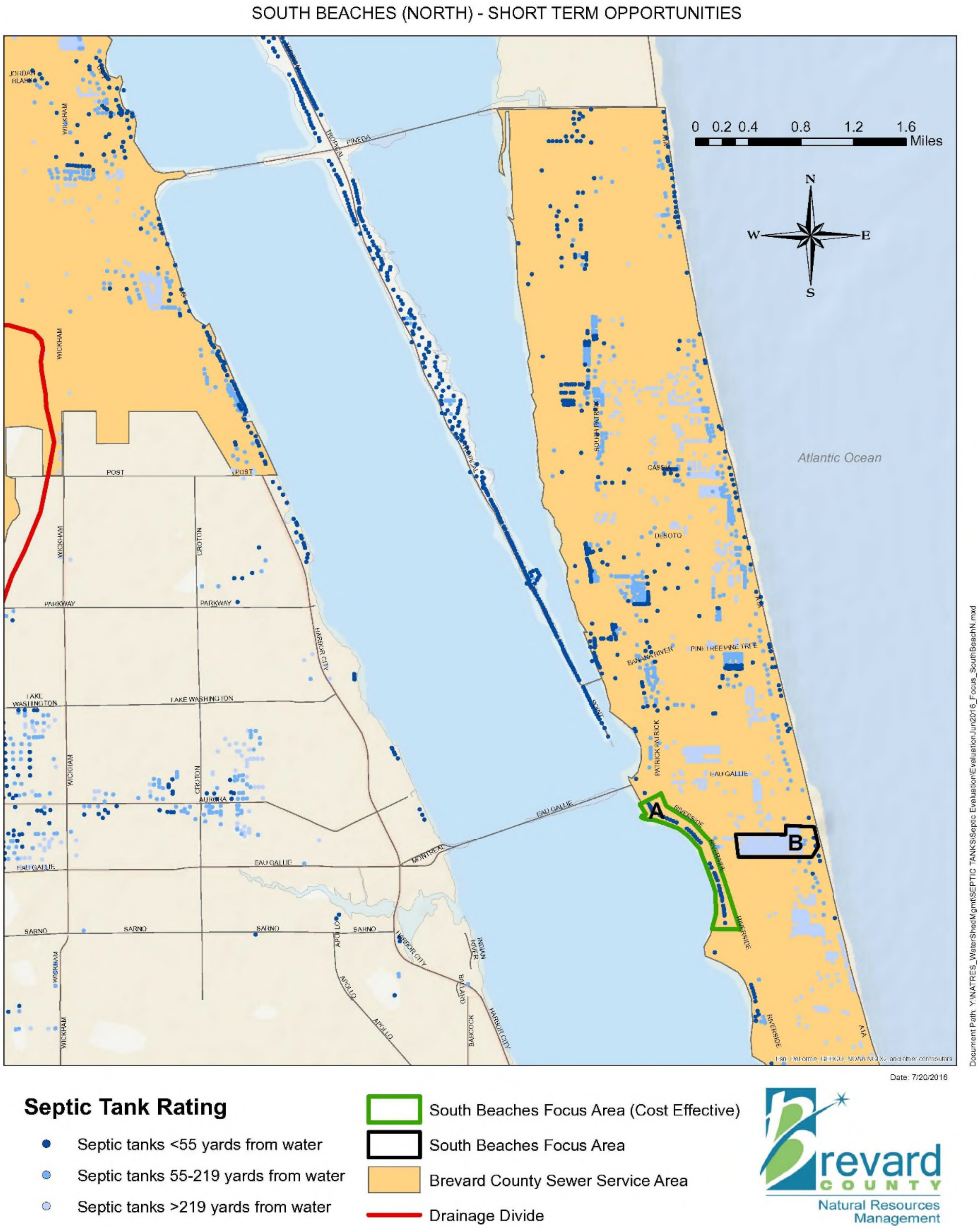
Appendix C: Maps of the Septic System Removal Areas Identified in the Original Plan

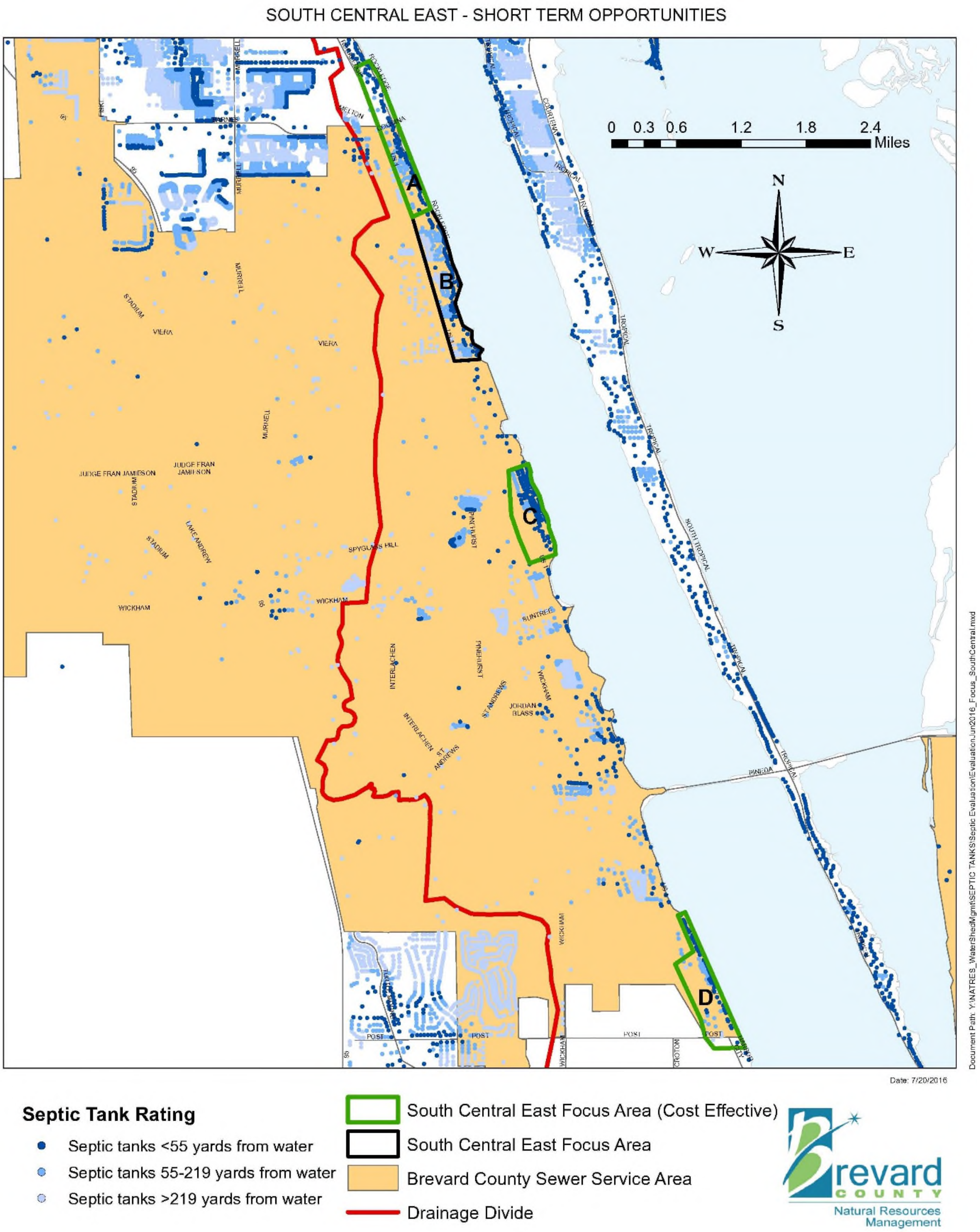
The septic systems within the unincorporated County were evaluated for connection to the central sewer system based on distance to a surface waterbody (ditch, canal, creek, or the IRL). Neighborhoods with a large number (approximately 50% or more) of septic systems within 55 yards of a surface water have the greatest impact on water quality and systems more than 219 yards from a surface water contribute very little TN loading. In **Figure C-1** through **Figure C-3**, the septic systems located within 55 yards of a surface waterbody are shown in the darkest blue and those systems that are further than 219 yards from a surface waterbody are shown in the lightest blue. On each map, the neighborhood focus areas that were evaluated for potential septic system removal are outlined in black. Those focus areas that were determined to be the most cost-effective for connection, and are therefore recommended for funding in this plan, are outlined in green.

The septic systems within the cities were also evaluated for potential connection to the sewer system. This evaluation was conducted by identifying those areas that had at least 50% of the septic systems within 55 yards of a surface waterbody. The scoring of these systems, as described in **Section 4.1.4**, were also considered. The septic systems with the highest (worst) score are shown in the darkest blue in **Figure C-4** through **Figure C-10**. The neighborhood focus areas proposed for septic system removal as part of this plan within the cities are outlined in green.



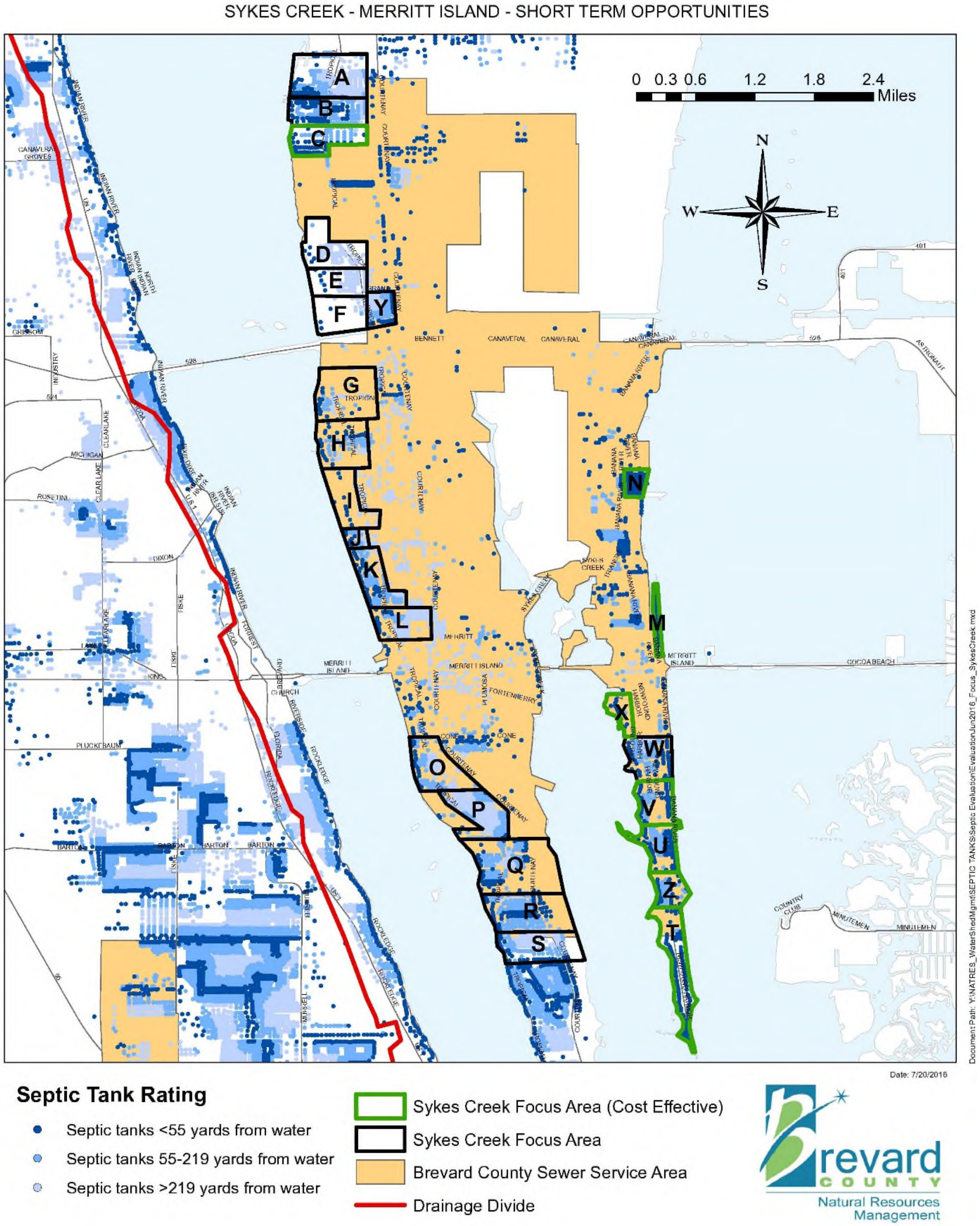
Notes: The focus areas outlined in green are the most cost-effective and are recommended as part of this plan. The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-1: Map of South Beaches Priority Septic System Areas



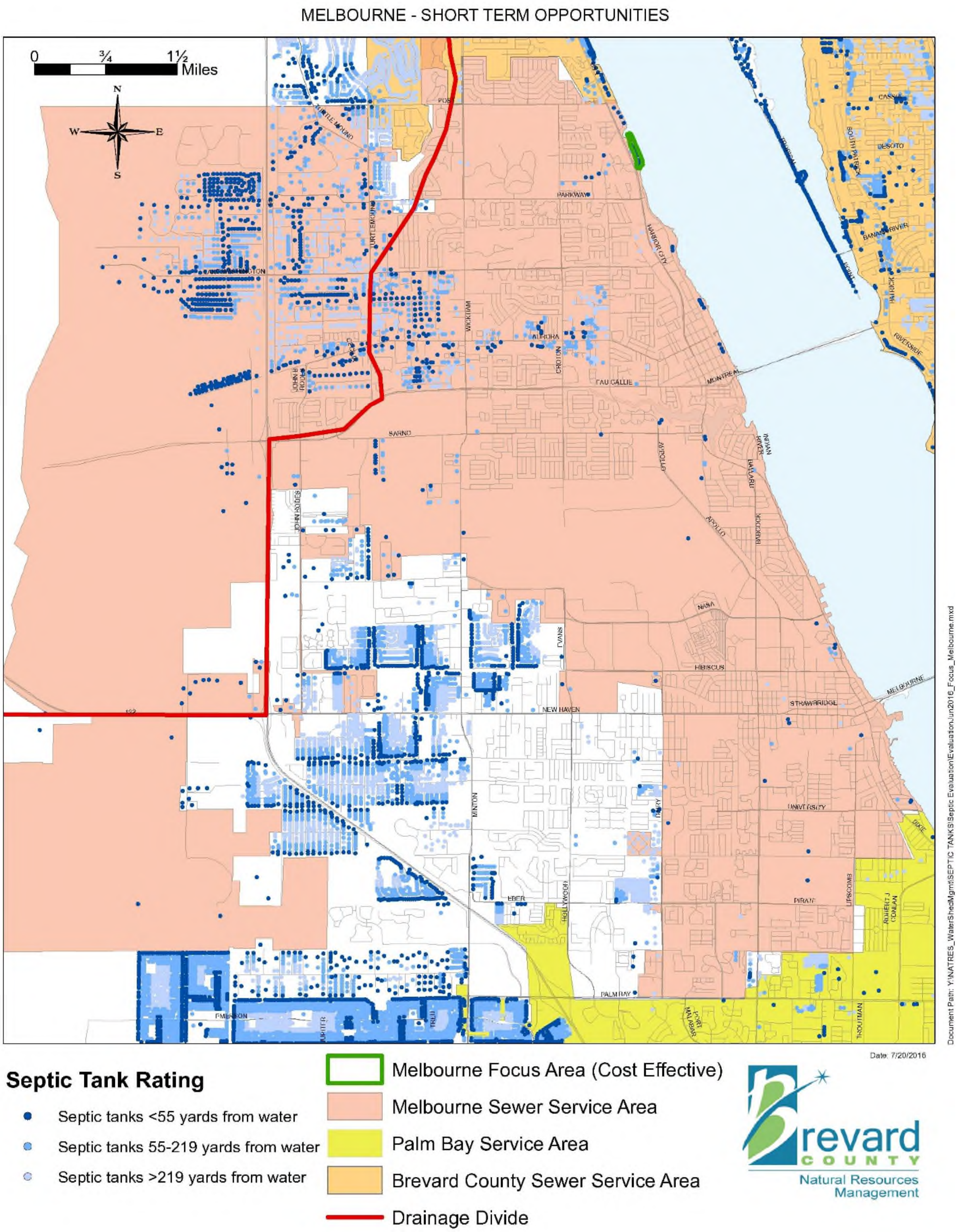
Notes: The focus areas outlined in green are the most cost-effective and are recommended as part of this plan. The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-2: Map of South Central Priority Septic System Areas



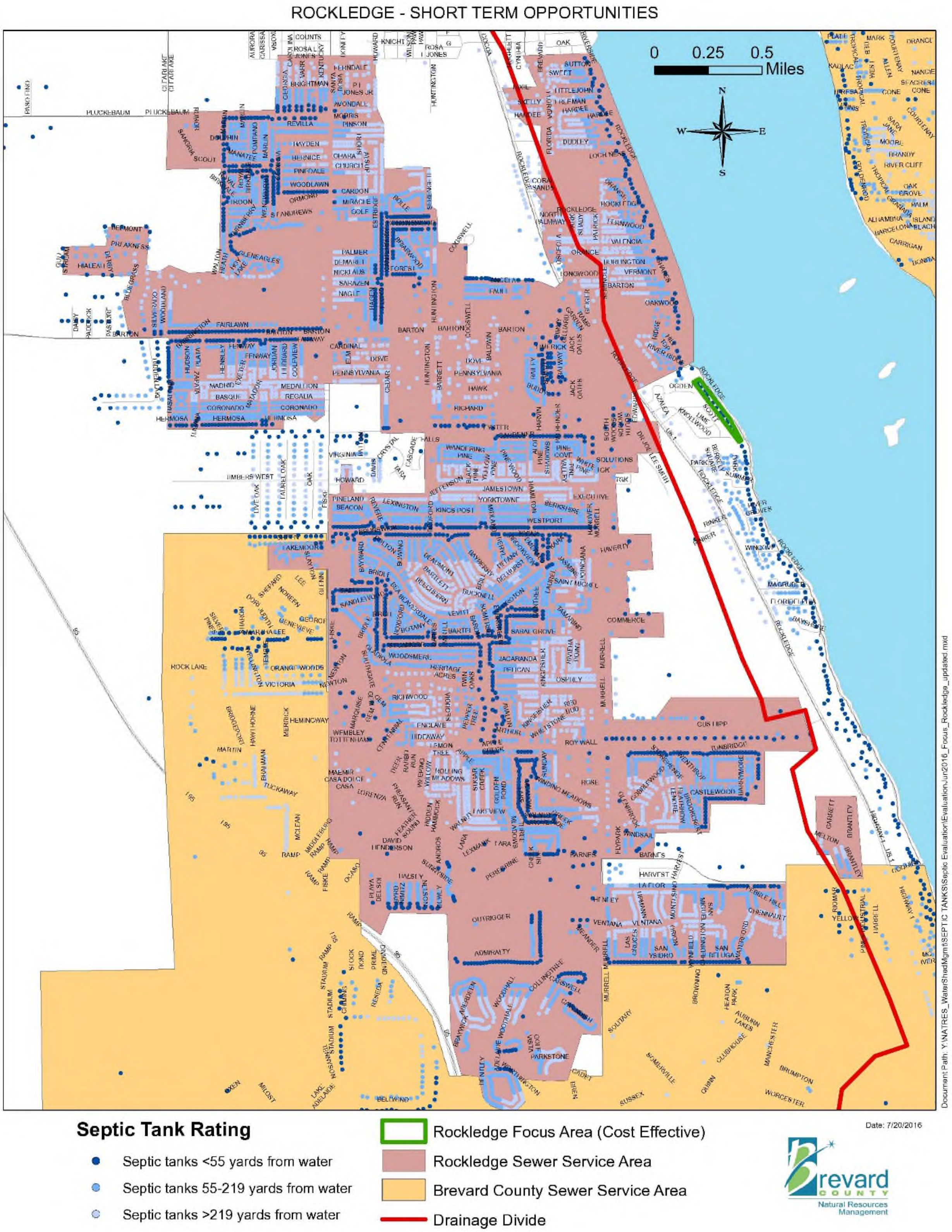
Notes: The focus areas outlined in green are the most cost-effective and are recommended as part of this plan. The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-3: Map of Sykes Creek Priority Septic System Areas



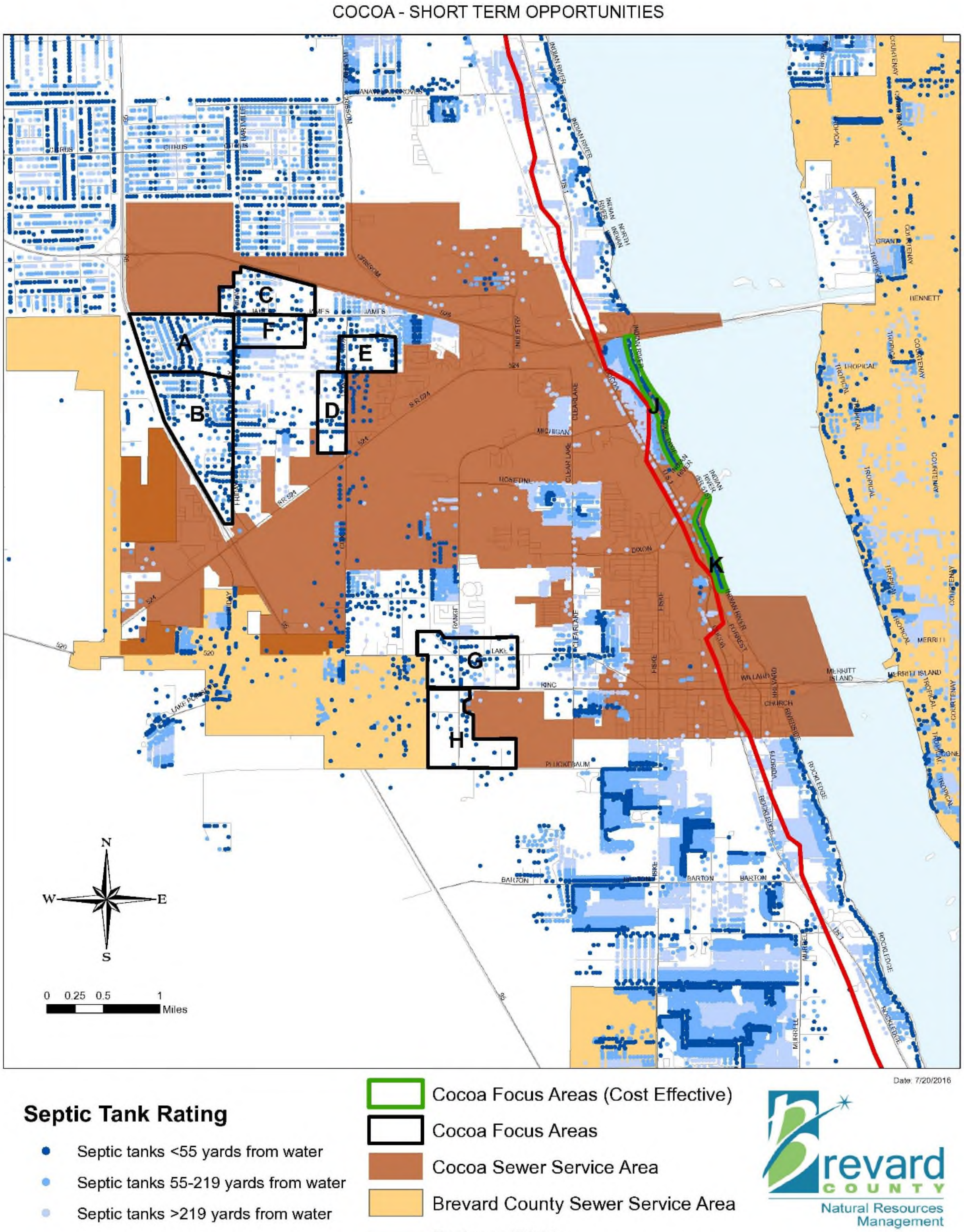
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-4: Map of City of Melbourne Priority Septic System Areas



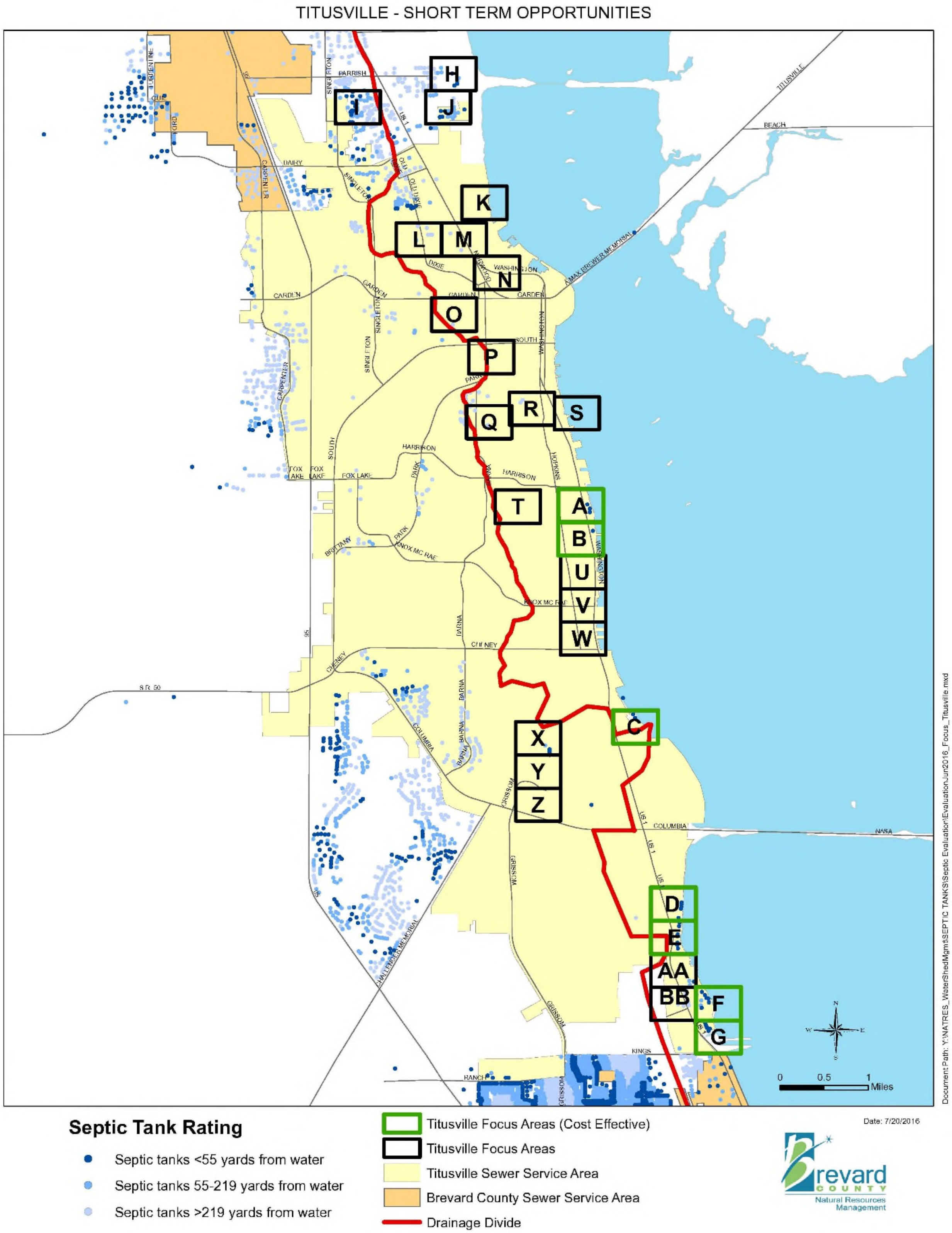
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-5: Map of City of Rockledge Priority Septic System Areas



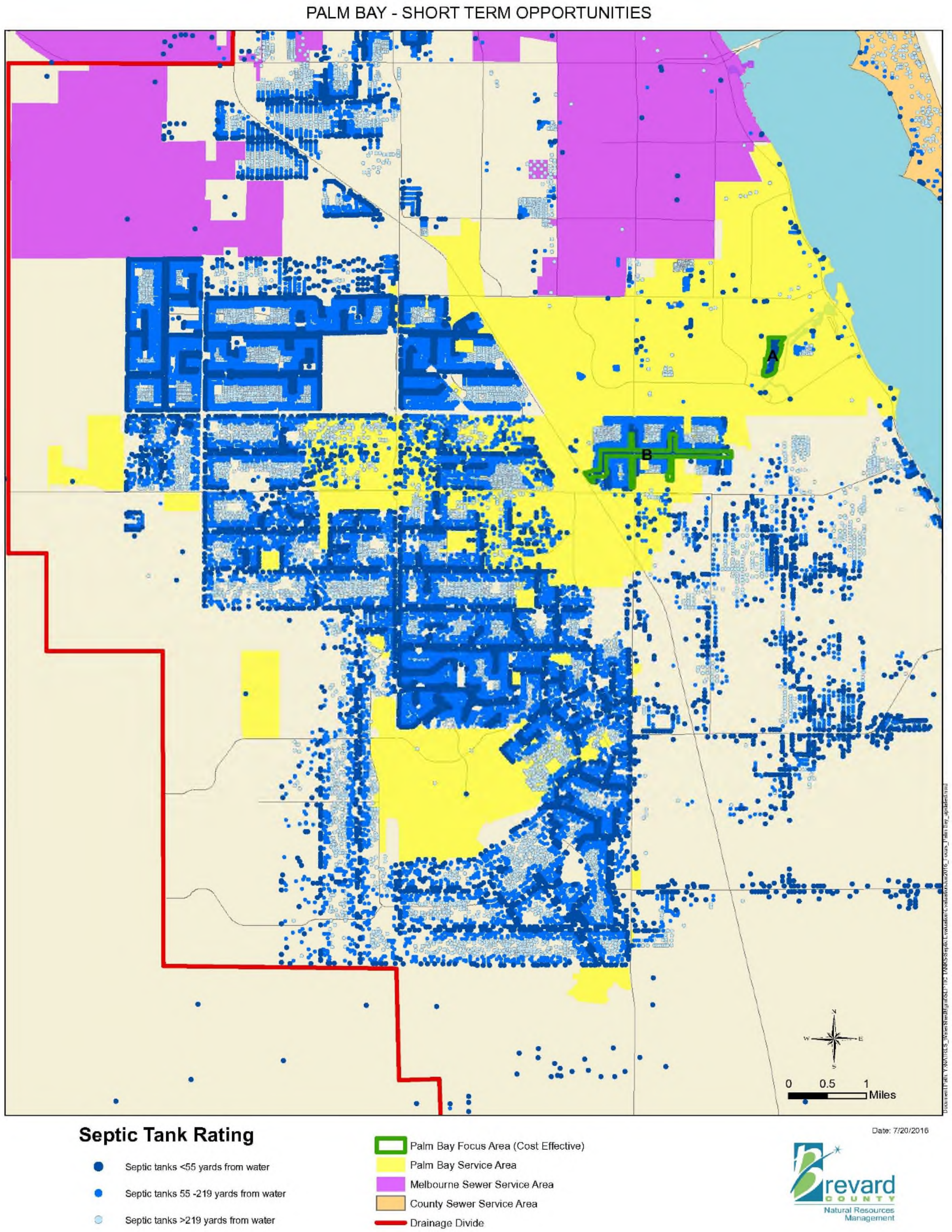
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-6: Map of City of Cocoa Priority Septic System Areas



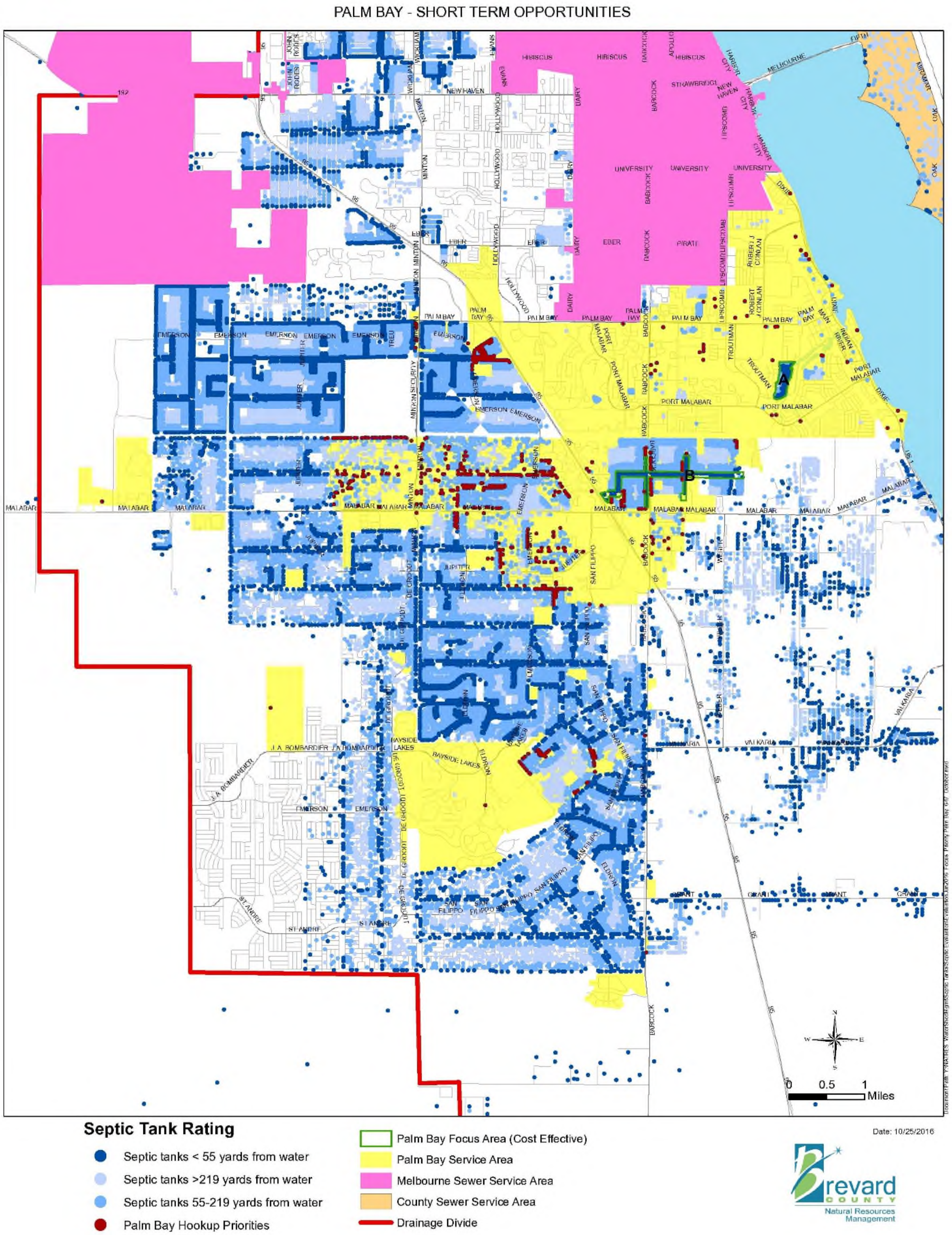
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-7: Map of City of Titusville Priority Septic System Areas



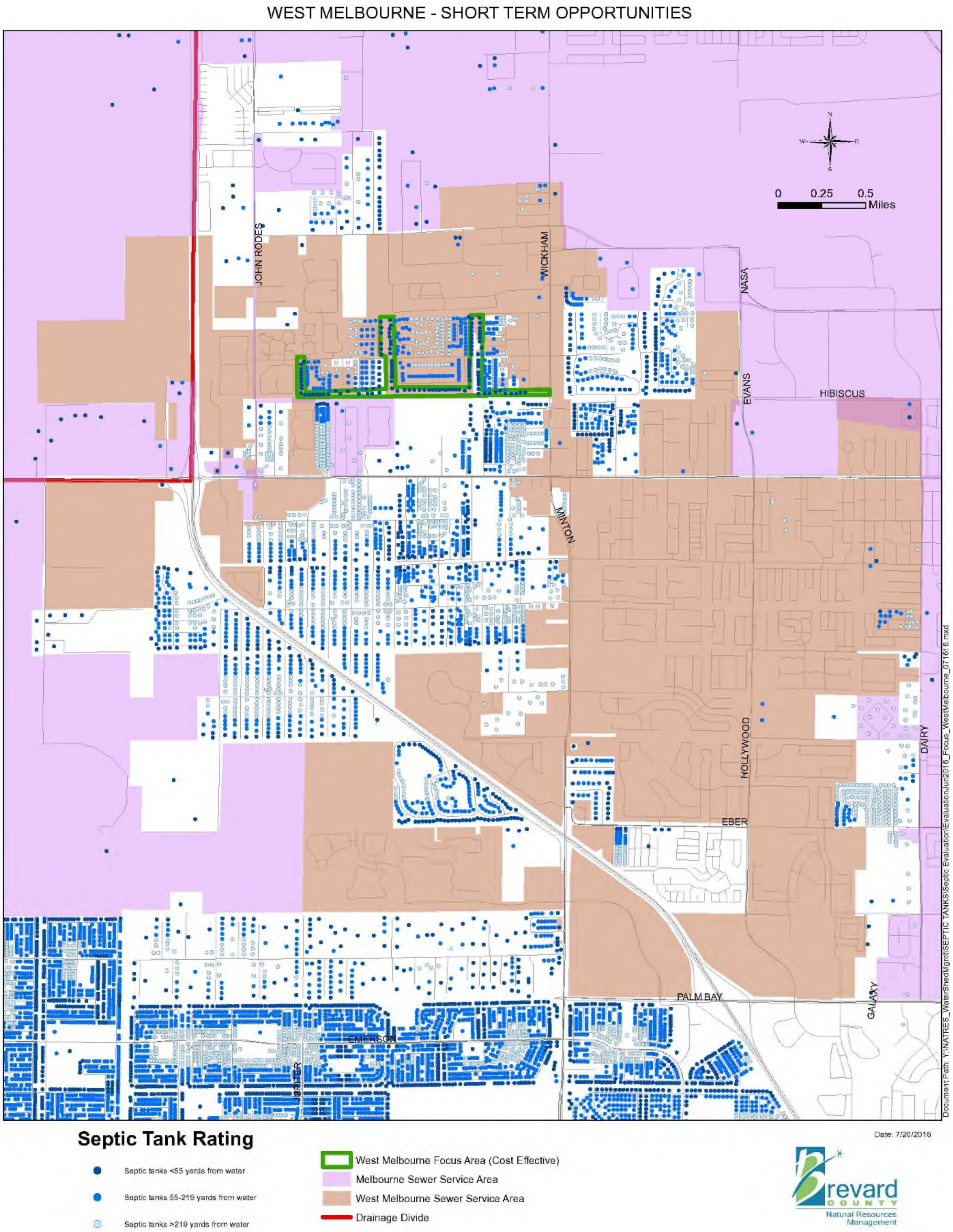
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-8: Map of City of Palm Bay Priority Septic System Areas



Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-9: Map of City of Palm Bay Septic System Areas Near Sewer Lines



Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure C-10: Map of City of West Melbourne Priority Septic System Areas

Appendix D: Summary of Stormwater Projects Identified in the Original Plan

Table D-1: Summary of TN Reductions from Stormwater Projects in Banana River Lagoon

Basin	Five-Month TN Load (lbs/yr)	TN % Efficiency	Five-Month TN Reductions (lbs/yr)	Annual TN Load (lbs/yr)	TN % Efficiency	Annual TN Reductions (lbs/yr)
~~979~~	~~1,549~~	~~55%~~	~~852~~	~~7,277~~	~~45%~~	~~3,275~~
~~1280~~	~~1,102~~	~~55%~~	~~606~~	~~3,855~~	~~45%~~	~~1,735~~
973	1,070	55%	588	4,552	45%	2,048
963	1,030	55%	566	4,649	45%	2,092
905	925	55%	509	2,540	45%	1,143
901	844	55%	464	3,685	45%	1,658
522	721	55%	397	1,766	45%	795
~~1317~~	~~717~~	~~55%~~	~~395~~	~~3,730~~	~~45%~~	~~1,679~~
650	707	55%	389	2,766	45%	1,245
1366	680	55%	374	3,295	45%	1,483
1343	625	55%	344	3,084	45%	1,388
492	613	55%	337	2,266	45%	1,020
476	596	55%	328	2,005	45%	902
1329	579	55%	319	2,916	45%	1,312
1350	577	55%	317	2,330	45%	1,049
815	559	55%	307	1,551	45%	698
992	554	55%	305	2,764	45%	1,244
388	544	55%	299	3,089	45%	1,390
1304	542	55%	298	2,562	45%	1,153
989	533	55%	293	2,290	45%	1,030
539	532	55%	293	2,474	45%	1,113
1071	522	55%	287	2,403	45%	1,082
350	518	55%	285	1,972	45%	888
1337	516	55%	284	2,492	45%	1,121
~~1063~~	~~513~~	~~55%~~	~~282~~	~~2,744~~	~~45%~~	~~1,235~~
1265	505	55%	278	1,652	45%	743
1222	502	55%	276	1,974	45%	888
1066	491	55%	270	2,575	45%	1,159
1172	491	55%	270	1,893	45%	852
820	490	55%	269	1,327	45%	597
~~970~~	~~488~~	~~55%~~	~~269~~	~~2,427~~	~~45%~~	~~1,092~~
~~995~~	~~477~~	~~55%~~	~~262~~	~~2,328~~	~~45%~~	~~1,048~~
~~998~~	~~472~~	~~55%~~	~~260~~	~~2,658~~	~~45%~~	~~1,196~~
451	471	55%	259	2,595	45%	1,168
943	469	55%	258	1,574	45%	708
821	463	55%	254	1,394	45%	627
705	460	55%	253	1,445	45%	650
~~1309~~	~~457~~	~~55%~~	~~251~~	~~2,257~~	~~45%~~	~~1,016~~
497	438	55%	579	2,374	45%	1,068
~~754~~	~~438~~	~~55%~~	~~578~~	~~1,631~~	~~45%~~	~~734~~
~~602~~	~~435~~	~~55%~~	~~574~~	~~2,374~~	~~45%~~	~~1,068~~

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Table D-2: Summary of TP Reductions from Stormwater Projects in Banana River Lagoon

Basin	Five-Month TP Load (lbs/yr)	TP % Efficiency	Five-Month TP Reductions (lbs/yr)	Annual TP Load (lbs/yr)	TP % Efficiency	Annual TP Reductions (lbs/yr)
~~979~~	~~213~~	~~65%~~	~~139~~	~~997~~	~~45%~~	~~448~~
~~1280~~	~~152~~	~~65%~~	~~99~~	~~525~~	~~45%~~	~~236~~
973	147	65%	96	691	45%	311
963	142	65%	92	880	45%	396
905	127	65%	83	395	45%	178
901	116	65%	76	435	45%	196
522	99	65%	65	245	45%	110
~~1317~~	~~99~~	~~65%~~	~~64~~	~~644~~	~~45%~~	~~290~~
650	97	65%	63	317	45%	143
1366	94	65%	61	537	45%	242
1384	85	65%	55	315	45%	142
492	84	65%	55	260	45%	117
476	82	65%	53	240	45%	108
1329	80	65%	52	469	45%	211
1350	79	65%	52	368	45%	165
815	77	65%	50	250	45%	113
992	76	65%	50	433	45%	195
388	75	65%	49	307	45%	138
1304	75	65%	49	385	45%	173
989	73	65%	48	244	45%	110
539	73	65%	48	258	45%	116
1071	72	65%	47	319	45%	144
350	71	65%	46	238	45%	107
1337	71	65%	46	413	45%	186
~~1063~~	~~71~~	~~65%~~	~~46~~	~~426~~	~~45%~~	~~192~~
1265	70	65%	45	219	45%	98
1222	69	65%	45	380	45%	171
1066	68	65%	44	413	45%	186
1172	68	65%	44	274	45%	123
820	67	65%	44	249	45%	112
~~970~~	~~67~~	~~65%~~	~~44~~	~~410~~	~~45%~~	~~185~~
~~995~~	~~66~~	~~65%~~	~~43~~	~~376~~	~~45%~~	~~169~~
~~998~~	~~65~~	~~65%~~	~~42~~	~~420~~	~~45%~~	~~189~~
451	65	65%	42	270	45%	121
943	65	65%	42	200	45%	90
821	64	65%	41	274	45%	123
705	63	65%	41	210	45%	95
~~1309~~	~~63~~	~~65%~~	~~41~~	~~338~~	~~45%~~	~~152~~
497	60	65%	39	249	45%	112
~~754~~	~~60~~	~~65%~~	~~39~~	~~211~~	~~45%~~	~~95~~
~~602~~	~~60~~	~~65%~~	~~39~~	~~241~~	~~45%~~	~~109~~

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Table D-3: Summary of TN Reductions from Stormwater Projects in North IRL

Basin	Five-Month TN Load (lbs/yr)	TN % Efficiency	Five-Month TN Reductions (lbs/yr)	Annual TN Load (lbs/yr)	TN % Efficiency	Annual TN Reductions (lbs/yr)
1273	1,150	55%	633	4,364	45%	1,964
1298	1,136	55%	625	3,810	45%	1,715
~~1430~~	~~1,135~~	~~55%~~	~~624~~	~~5,011~~	~~45%~~	~~2,255~~
1349	1,094	55%	602	4,601	45%	2,070
1439	1,044	55%	574	3,141	45%	1,413
1445	1,042	55%	573	3,319	45%	1,493
626	985	55%	542	3,560	45%	1,602
454	919	55%	505	4,435	45%	1,996
1416	915	55%	503	3,997	45%	1,799
1324	911	55%	501	3,160	45%	1,422
1077	895	55%	492	3,748	45%	1,687
1256	870	55%	478	3,520	45%	1,584
1335	789	55%	434	3,784	45%	1,703
1419	780	55%	429	4,155	45%	1,870
1409	764	55%	420	3,000	45%	1,350
1377	717	55%	395	3,375	45%	1,519
~~327~~	~~713~~	~~55%~~	~~392~~	~~4,443~~	~~45%~~	~~1,999~~
1342	696	55%	383	2,608	45%	1,174
219	662	55%	364	2,125	45%	956
47	660	55%	363	2,996	45%	1,348
1434	656	55%	361	2,071	45%	932
1151	655	55%	360	2,348	45%	1,057
1078	655	55%	360	2,778	45%	1,250
1399	651	55%	358	3,488	45%	1,570
1301	651	55%	358	2,277	45%	1,025
1368	646	55%	355	2,912	45%	1,311
408	641	55%	352	2,620	45%	1,179
338	633	55%	348	4,226	45%	1,902
1367	618	55%	340	2,316	45%	1,042
1384	618	55%	340	2,051	45%	923
1318	609	55%	335	2,497	45%	1,124
155	594	55%	327	2,553	45%	1,149
289	590	55%	324	2,471	45%	1,112
193	583	55%	321	2,925	45%	1,316
1441	577	55%	762	2,298	45%	1,034
660	576	55%	761	1,876	45%	844
952	575	55%	759	2,780	45%	1,251

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Table D-4: Summary of TP Reductions from Stormwater Projects in North IRL

Basin	Five-Month TP Load (lbs/yr)	TP % Efficiency	Five-Month TP Reductions (lbs/yr)	Annual TP Load (lbs/yr)	TP % Efficiency	Annual TP Reductions (lbs/yr)
1273	158	65%	103	640	45%	288
1298	156	65%	102	511	45%	230
~~1430~~	~~156~~	~~65%~~	~~102~~	~~745~~	~~45%~~	~~335~~
1349	151	65%	98	721	45%	324
1439	144	65%	93	407	45%	183
1445	144	65%	93	441	45%	198
626	136	65%	88	430	45%	193
454	126	65%	82	671	45%	302
1416	126	65%	82	508	45%	229
1324	125	65%	82	391	45%	176
1077	123	65%	80	641	45%	289
1256	120	65%	78	533	45%	240
1335	109	65%	71	578	45%	260
1419	107	65%	70	594	45%	267
1409	105	65%	68	455	45%	205
1377	99	65%	64	546	45%	246
~~327~~	~~98~~	~~65%~~	~~64~~	~~629~~	~~45%~~	~~283~~
1342	96	65%	62	386	45%	174
219	91	65%	59	251	45%	113
47	91	65%	59	309	45%	139
1434	90	65%	59	248	45%	112
1151	90	65%	59	314	45%	141
1078	90	65%	59	416	45%	187
1399	90	65%	58	569	45%	256
1301	90	65%	58	342	45%	154
1368	89	65%	58	445	45%	200
408	88	65%	57	378	45%	170
338	87	65%	57	418	45%	188
1367	85	65%	55	324	45%	146
1384	85	65%	55	315	45%	142
1318	84	65%	54	328	45%	148
155	82	65%	53	271	45%	122
289	81	65%	53	495	45%	223
193	80	65%	52	440	45%	198
1441	79	65%	52	331	45%	149
660	79	65%	52	470	45%	212
952	79	65%	51	471	45%	212

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Table D-5: Summary of TN Reductions from Stormwater Projects in Central IRL

Basin	Five-Month TN Load (lbs/yr)	TN % Efficiency	Five-Month TN Reductions (lbs/yr)	Annual TN Load (lbs/yr)	TN % Efficiency	Annual TN Reductions (lbs/yr)
1562	1,975.9	55.0%	1,086.8	7,365.0	45.0%	3,314.2
1762	1,652.4	55.0%	908.8	7,061.1	45.0%	3,177.5
1615	1,397.6	55.0%	768.7	6,256.6	45.0%	2,815.5
~~1582~~	~~1,392.9~~	~~55.0%~~	~~766.1~~	~~5,338.1~~	~~45.0%~~	~~2,402.1~~

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Table D-6: Summary of TP Reductions from Stormwater Projects in Central IRL

Basin	Five-Month TP Load (lbs/yr)	TP % Efficiency	Five-Month TP Reductions (lbs/yr)	Annual TP Load (lbs/yr)	TP % Efficiency	Annual TP Reductions (lbs/yr)
1562	272.1	65.0%	176.9	997.8	45.0%	449.0
1762	227.5	65.0%	147.9	1,093.3	45.0%	492.0
1615	192.4	65.0%	125.1	866.6	45.0%	390.0
~~1582~~	~~191.8~~	~~65.0%~~	~~124.7~~	~~984.7~~	~~45.0%~~	~~443.1~~

Note: Projects with strikethrough were removed as part of the 2018 Plan Update because they could not be easily treated or are basins where the County and local governments already have projects.

Appendix E: Seagrasses

Loss of Seagrass

In partnership, the St. Johns River Water Management District, South Florida Water Management District, and Florida Department of Environmental Protection mapped seagrass from aerial imagery taken in 1943 and every two to three years since 1986 (**Figure E-1**). Through 2009, the areal footprint of seagrass generally expanded, with some areas nearing their targets, which are benchmarks used to evaluate the success of reducing loads of nutrients to the IRL system. Unfortunately, the areal extent of seagrass in the lagoon began to decline in 2011. In 2011, mapping documented a loss of almost 43% of the acreage present in 2009. Most of this loss occurred in the reaches adjacent to Brevard County, with extensive losses in Banana River Lagoon (24,000 to 3,000 acres or an 88% reduction) and the IRL down to Sebastian Inlet (50,000 to 20,000 acres or a 60% reduction). The losses occurred during a bloom of phytoplankton (single-celled algae) that reached unprecedented concentrations for a record duration as indicated by concentrations of chlorophyll-*a* (**Figure E-2**). Beyond the shallowest water, the bloom effectively reduced the amount of light reaching seagrasses below what they required for survival. Additional intense blooms exacerbated the situation.

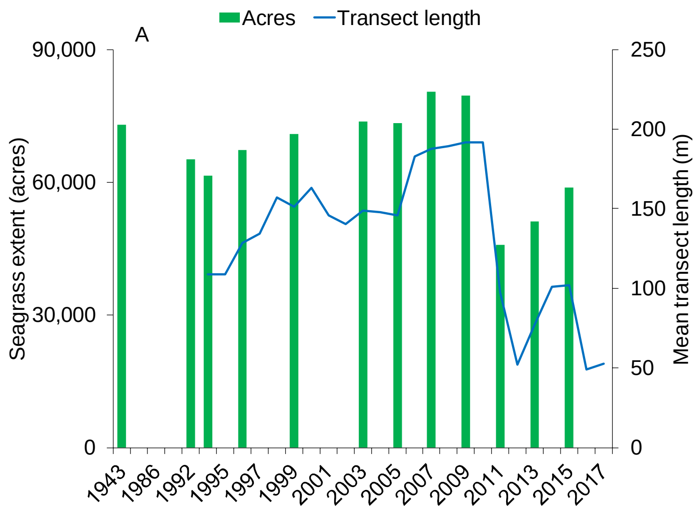


Figure E-1: Mean Areal Extent of Seagrass and Mean Length of Transects

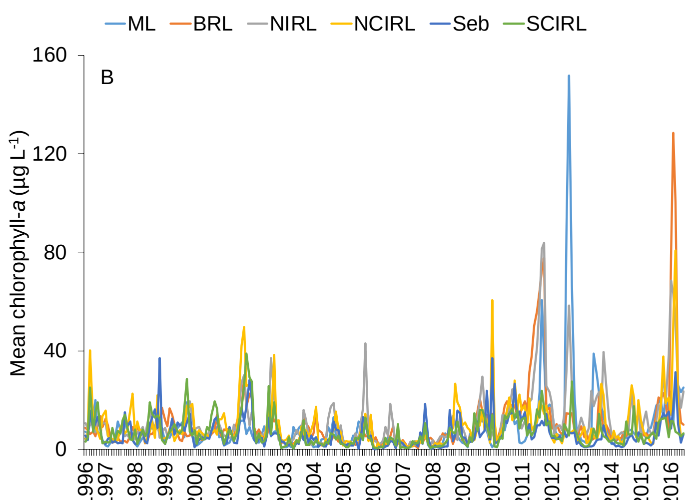
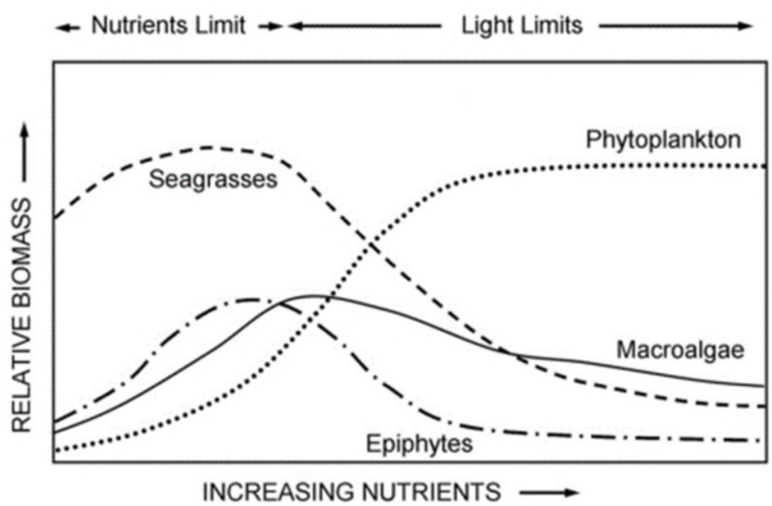


Figure E-2: Mean Chlorophyll-*a* Concentrations

Since 2011, some seagrass acreage has returned. In the IRL along Brevard County, about 9,000 acres have returned or about 30% of the 30,000 acres that were lost. In addition, there has been a similar amount of recovery in Banana River Lagoon (6,000 acres returned out of 21,000 lost or about 30% recovery). Recovery has been hampered by further blooms that include a brown tide (*Aureoumbra lagunensis*) bloom in 2016, whose effects will be apparent in maps produced from digital photography acquired in 2017. The prognosis is not good because the percentage cover of seagrass reached 5%, which is a record drop from 30–50% (**Figure E-1**).

Unfortunately, the IRL appears to be following a pattern described for systems that receive increased loads of nutrients (Duarte 1995; Burkholder et al. 2007). The pattern involves a shift in the composition of the primary producer assemblage, with higher nutrient loads differentially promoting faster growing macroalgae and ultimately phytoplankton (**Figure E-3**). The macroalgae and phytoplankton can exacerbate loss of seagrasses, especially by shading them. Loss of seagrass and macroalgae makes more nutrients available to phytoplankton, and loss of seagrass means that the sediments can be resuspended, which also reduces light penetration. Overall, the change in the system becomes self-perpetuating. Reducing nutrient loads represents a critical first step in efforts to reverse the shift in primary producers. However, a return to the previous areal coverage of seagrass may take some time, especially if too few recruits are available and sediments are too destabilized for colonization.



Note: Adapted from Burkholder et al. 2007

Figure E-3: Conceptual Model Illustrating a Shift in Biomass Among Major Primary Producers with Increasing Nutrient Enrichment

Nutrient Content of Seagrass

Halodule wrightii stores nutrients in its aboveground and belowground biological material or biomass. The biomass of this and other seagrasses changes seasonally, with peak growth of aboveground shoots occurring in April and May and the greatest aboveground biomass recorded during summer. These seasonal changes introduce uncertainty into estimates of nutrient storage, but mean values will suffice for estimating return on investment in the long-term (**Table E-1**). For example, a single shoot of *H. wrightii* may contain up to five or more leaves in the summer, whereas in the winter this same shoot may contain only one leaf (Dunton 1996). For this estimate of nutrient content, we will assume that spring-summer growth and fall-winter senescence are equal. Thus, we will focus on our recent estimates of an average amount of aboveground and belowground biomass or standing stock of *H. wrightii* (**Table E-1** and **Table E-2**).

Table E-1: Estimates of Biomass for *Halodule* Species

Location	Total Biomass (grams dry weight/m^2)	Reference
Texas (Laguna Madre)	10–400	Zieman and Zieman 1989
North Carolina (multiple locations)	22–208	Zieman and Zieman 1989
South Florida and Tampa Bay	10–300	Zieman and Zieman 1989
IRL (Fort Pierce Inlet)	124–198	Hefferman and Gibson 1983
IRL (Grand Harbor/Vero)	45	Hefferman and Gibson 1983
IRL (Link Port)	20–140	Virnstein unpublished
IRL (Brevard County)	53*	Morris, Chamberlain, and Jacoby unpublished
Texas (Laguna Madre)	10–400	Zieman and Zieman 1989

* Mean aboveground biomass = 23 grams dry weight m^{-2} = [(mean percent cover × 30.533) × 0.019]; mean belowground biomass = 30 grams dry weight m^{-2} = 1.3 × aboveground biomass

Table E-2: Total Biomass in Seagrasses Along Brevard County

Sublagoon	Description	Total Biomass (grams dry weight/m^2)	
Mosquito Lagoon	Brevard County line to southern end of sublagoon	74	74
Banana River Lagoon	NASA restricted area	64	53
Banana River Lagoon	Remainder of Banana River Lagoon	44	
IRL	North of SR-405	51	44
IRL	SR-405 to Pineda Causeway	35	
IRL	Pineda Causeway to Hog Point	28	39
IRL	Hog Point to Brevard County line	51	
Mean	***N/A***	***50***	***53***

Duarte (1990) compared nutrient contents of 27 species of seagrass, including *H. wrightii*. He determined that nitrogen and phosphorus represent about 2.2% and 0.2% of the dry weight of aboveground and belowground tissue of *H. wrightii*, respectively. These values are similar to those calculated during a recent study in the IRL (**Table E-3**). The values can be combined with estimates of biomass to calculate how much nitrogen and phosphorus are sequestered by 100 acres of *H. wrightii* on average (**Table E-4**).

Table E-3: Estimates of Nutrient Content for *Halodule* species

Location	Nutrient content for *Halodule wrightii* (percentage of dry weight)					
	Aboveground			Belowground		
	Carbon	Nitrogen	Phosphorus	Carbon	Nitrogen	Phosphorus
BRL-1	29.60	2.02	0.17	30.60	1.24	0.14
BRL-2	30.60	2.36	0.24	29.08	1.47	0.27
BRL-3	29.60	2.66	0.26	28.09	1.48	0.25
IRL-1	31.74	2.39	0.18	31.69	1.42	0.15
IRL-2	30.08	2.56	0.26	30.48	1.74	0.27
IRL-3	28.26	2.08	0.25	23.86	1.36	0.20
Mean	***29.98***	***2.35***	***0.23***	***28.97***	***1.45***	***0.21***

BRL = Banana River Lagoon, IRL = Indian River Lagoon

Table E-4: Average Amount of Nutrients Contained in Seagrass from 1996–2009

Sub-Lagoon	Acres	Seagrass (lbs/100 acres)	Nitrogen (lbs/100 acres)	Phosphorus (lbs/100 acres)
Southern Mosquito Lagoon	14,000	45,000	1,000	100
Banana River Lagoon	21,000	45,000	1,000	100
North IRL	19,000	37,000	900	90
Central IRL	7,000	36,000	900	90

Draft Evaluation Criteria for Planting Seagrass

Part of the wisdom accumulated from past seagrass restoration projects is the importance of selecting sites that will support seagrass growth. Key information has been synthesized into an initial guide, with higher scores and more certainty indicating better sites for planting seagrass (**Table E-5**). Please note that the presence of seagrass leads to a lower score based on the premise that natural recruitment represents the most cost-effective option for restoring seagrass. In addition, a high level of uncertainty can suggest targets for further study. This guide can be refined following pilot studies to determine optimal methods for planting seagrass (e.g., type of planting units, use of chemicals to enhance growth, and density of initial planting) and protecting it from disturbance (e.g., grazing, waves, exposure, and low salinity) until it is established.

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Hefferman J.J., and R.A. Gibson. 1983. A comparison of primary production rates in Indian River, Florida seagrass systems. Florida Scientist 46: 295–306.

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Table E-5: Guide for Ranking Potential Seagrass Restoration Sites

Category	Metric	Timeframe	Scores and attributes				Score	Uncertainty 1 = low, 3 = high
			Score = 0	Score = 2	Score = 4	Score = 6		
Critical Depth Zone (CDZ) 0.5-0.8 m below mean sea level (MSL)	**Width of CDZ** (distance perpendicular to shore)	**Recent**	**Very narrow:** < 25 m wide (< 82 ft)	**Narrow:** 25-50 m (82-164 ft)	**Moderately wide:** 50-100 m (164-328 ft)	**Broad:** > 100 m (> 328 ft)		
	Distance to seagrass (identified via the most recent map or targeted reconnaissance)	**Recent**	**Continuous seagrass at site and within 1 km (FLUCCS code = 9116):** seagrass is a dominant feature (restoration not needed)	**Isolated:** no seagrass within 1 km (0.6 miles) so conditions may be unfavorable	**Discontinuous seagrass at site and within 1 km (FLUCCs code = 9113):** seagrass is patchy so restoration may connect patches	**Seagrass nearby:** seagrass within 0.5-1.0 km (0.3-0.6 miles)		
	Percent cover in CDZ (derived from the closest transect, paired considerations)	**Past** (2000-2009)	**High:** > 30%	**Low:** 10-20%	**Moderate:** 20-30%	**High:** > 30%		
		Last 3 Years	**High:** > 10% (restoration not needed)	**Low:** < 10% (restoration may not help)	**Low:** < 10% (restoration may help but ultimate gain is likely limited)	**Low:** < 10% (potentially optimum site for restoration)		
Potential stressors	**Water quality** (salinity and light availability derived from the closest station)	**Last 3 Years**	**Bad:** salinity < 10 anytime and < 18 for ³ 3 consecutive months or annual mean salinity - 1 standard deviation < 17 Secchi depth £ 0.50 m (1.6 ft) anytime and £ 0.65 m (2.1 ft) for ³ 3 consecutive months or annual mean Secchi depth - 1 standard deviation £ 0.65 m	**Poor:** salinity < 18 for 3 consecutive months but never < 12 or annual mean salinity - 1 standard deviation³ 17 Secchi depth £ 0.65 m for < 3 consecutive months but never £ 0.50 m or annual mean Secchi depth - 1 standard deviation ³ 0.65 m	**Supportive:** salinity always ³ 18 Secchi depth always > 0.65 m and may be 0.65-1.0 m (2.1-3.3 ft) for 3 consecutive months	**Good:** salinity consistently ³ 23 Secchi depth consistently > 1.0 m		
	Sediment (assessed via visits to the site or other current information)	**Present**	**Not supportive:** anoxic and sulfidic near the surface or easily resuspended or moved	**Minimally supportive:** hard bottom (e.g., compact sand or shells), not conducive for growth of rhizomes and roots, porewater may lack nutrients	**Generally supportive:** unconsolidated sediment that holds plants with relatively little resuspension and movement observed, porewater nutrients not limiting	**Fully supportive:** loosely consolidated sediment with firmly anchored plants if present, anoxic and sulfidic layers located below the zone occupied by roots and rhizomes, porewater rich in nutrients		
	Water movement (assessed via visits to the site or other current information)	**Present**	**High currents - possible scouring:** frequent and strong currents or waves that may cause ripples in the sediment and uproot new plants	**Moderate to high currents: c**urrents and waves bend plants, sweep fragments of seagrass away before they can gain a foothold, and cause some resuspension of sediment	**Moderate currents:** plants often stand upright, fragments of seagrass may be trapped, sediment typically not resuspended	**Low currents:** mild currents or waves, sediment not disturbed, no apparent negative effects on any seagrass that is present		
	Shoreline characteristics (assessed via visits the site or other current information)	**Present**	**Unnatural shoreline:** CDZ in close proximity to urban development, including canals, and a hardened shoreline (e.g., riprap or bulkhead)	**Semi-natural shoreline:** CDZ near moderate development and some shoreline is vegetated	**Mostly natural shoreline:** CDZ near low to moderate development, most of the shoreline is vegetated shoreline or the site is associated with living shoreline project	**All natural shoreline:** vegetated shoreline with very limited development		
	Public use (assessed via visits to the site visits or other current information, including recent aerial photographs)	**Present**	**High use:** CDZ adjacent to or within an area with frequent boating, swimming or fishing (e.g., aerial photographs show prop scars)	**Near high use:** CDZ within 0.5 km (0.3 miles) of a highly used area	**Not near high use:** CDZ more than 0.5 km from a highly used area	**Low use:** no public facilities nearby and limited signs of use		
	Biota (assessed via visits to the site or other current information on grazing or physical disturbance)	**Present**	**Heavy use:** site adjacent to deep water or manatee zone, power plant within 10 km (6.2 miles), freshwater nearby, manatees and rays observed frequently, disturbance or grazing evident in > 50% of the area on a weekly-monthly basis	**Moderate use:** power plant > 10 km away, deep water and manatee zones > 0.5 km away, no freshwater nearby, disturbance or grazing evident in < 50% of the area on a monthly basis	**Intermittent use:** disturbance or grazing evident in < 25% of the area on a quarterly basis	**Rare use:** disturbance or grazing hardly evident		
Logistics	**Enhancement or protection** (assessed via visits to the site)	**Present**	**Extensive need:** dense planting required due to absence of seagrass, fencing or caging required due to grazing, other enhancement or protection required, including living shorelines, sediment barriers, wave baffles	**Substantial need:** moderately dense planting required because only 1-2% cover present, fencing or caging required, few additional enhancements or protections required	**Moderate need:** low density planting sufficient because at least 2% cover present, fencing or caging required for a limited time, other enhancements or protections beneficial but not critical	**Limited need:** minimal density planting or no planting required because > 2% cover present and protection from grazing may result in spread of seagrass, no other enhancements or protections required		
	Maintenance (assessed via visits to the site)	**Anticipated**	**High maintenance:** weekly cleaning	**Moderate maintenance:** monthly cleaning	**Low maintenance:** quarterly cleaning	**Minimum maintenance:** maintain as needed		
	Staging and accessibility (assessed via visits to the site)	**Present**	**Very difficult:** substantial impediments that may include boat ramps **>** 10 km away, soft sediment that is easily disturbed, permitting and access issues	**Moderately difficult:** boat ramp within 10 km, somewhat firm sediment, tractable permitting and access issues	**Relatively simple:** boat ramp nearby and few other issues	**No issues**		
	Monitoring (relevant past, current and future information on water quality and seagrasses available)	**Present**	**No external support:** no sampling of seagrass within 5 km (3.1 miles), nearest water quality station not representative of conditions at the site	**Minimal external support:** seagrass surveyed within 3-5 km (1.9-3.1 miles), water quality station is representative of conditions at the site	**Moderate external support:** seagrass and water quality sampled within 3 km so both are representative of conditions at the site	**Considerable external support:** seagrasses and water quality sampled at or adjacent to the site		
Total	**Notes:** Optimize potential for success by planting: a) within the CDZ (e.g., at 0.6-0.8 m below MSL) with due recognition of tides and annual changes in water levels; or b) during the spring (e.g., late March to May) when water clarity is best, water temperatures are warming, and grazing by fish is relatively low Scoring: if conditions do not match the attributes provided, then assign a score between the two that are most applicable							