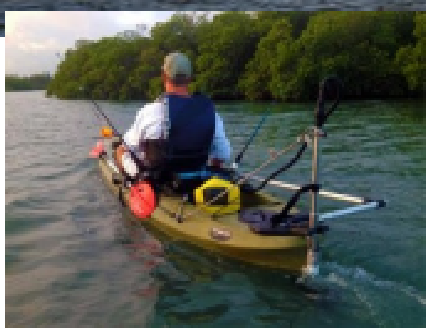
Attachment A

Save Our Lagoon Project Plan
for
Brevard County, Florida



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Brevard County

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List of Acronyms

AFB	Air Force Base
BAM	Biosorption Activated Media
BMAP	Basin Management Action Plan
BMP	Best Management Practice
CBPO	Chesapeake Bay Program Office
CCMP	Comprehensive Conservation and Management Plan
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
FWC	Florida Fish and Wildlife Commission
FY	Fiscal Year
GI	Green Infrastructure
GIS	Geographic Information System
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
SJRWMD	St. Johns River Water Management District
SRF	State Revolving Fund
STEAM	Science Technology and Economic Adaptive Management (team)
STEP	Septic Tank Effluent Pumping (system)
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 is proposing to place a Save Our Lagoon referendum on the ballot in November 2016. This referendum would provide a funding stream for the types of projects listed in this plan for Brevard County and its municipalities.

This Save Our 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 referendum. This referendum 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. 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 substitute 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.

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 the Project Types, Costs, and Nutrient Reductions from the Save Our 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	Fertilizer Management/Public Education	$625,000	6,123	$102	813	$769
	WWTF Upgrades for Reclaimed Water	$9,400,000	40,778	$214	TBD	TBD
	Septic System Removal	$41,764,000	56,509	$852	N/A	N/A
	Septic System Upgrades	$22,192,000	27,659	$802	N/A	N/A
	Stormwater Projects	$10,800,000	118,440	$88	17,026	$612
Remove	Muck Removal	$198,100,000	491,300	$408	73,650	$2,733
Restore	Oyster Reef Living Shorelines	$10,000,000	21,120	$473	7,181	$1,393
Respond	Projects Monitoring	$10,000,000	N/A	N/A	N/A	N/A
Total	***Total***	***$302,881,000***	***761,929***	***N/A***	***98,670***	***N/A***

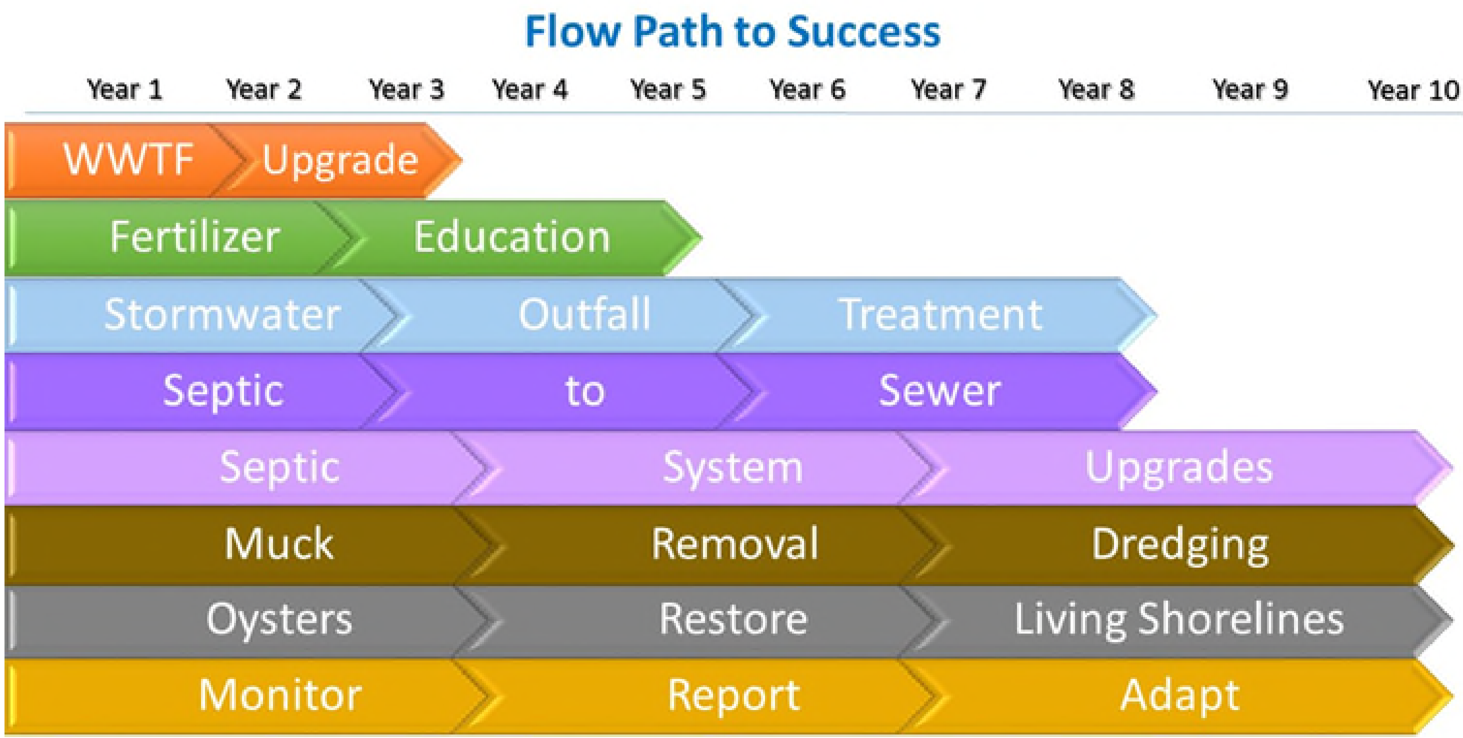


Figure ES-1: Save Our Lagoon Project Implementation Schedule

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 is proposing to place a Save Our Lagoon referendum on the ballot in November 2016. This referendum would provide a funding mechanism for the projects listed in this plan (or future annual updates) for the County and its municipalities. If the referendum passes, revenue collection would begin during 2017.

This Save Our 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 are contingent upon additional fundraising. Furthermore, additional local 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. 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 referendum 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.

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.

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***

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.

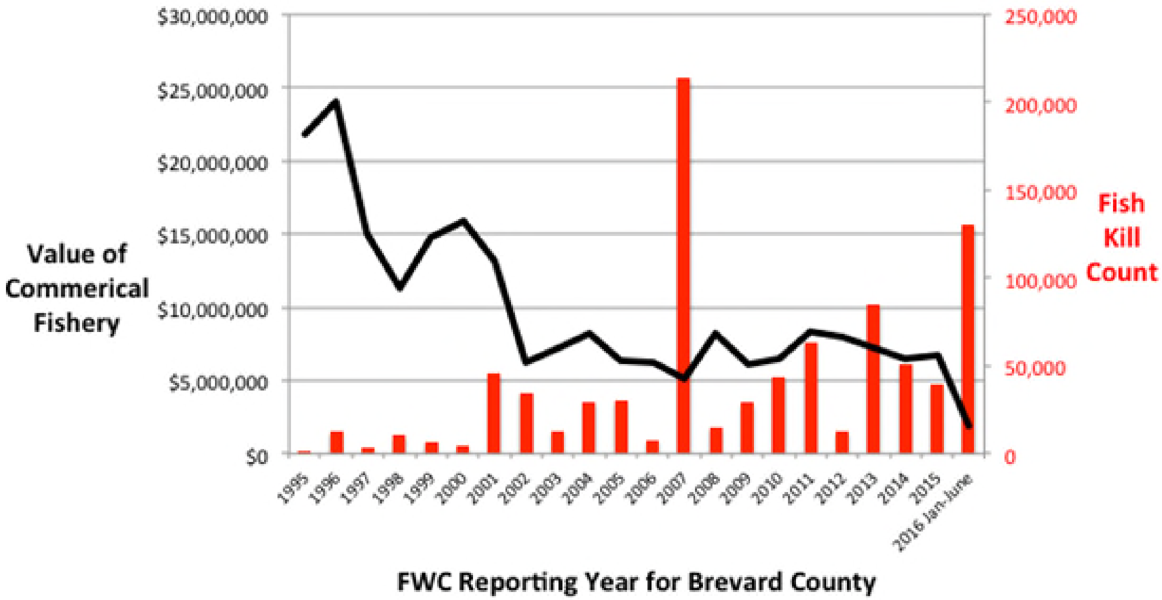


Figure 1: Decline of Commercial Fishing and Increasing Fish Kill Severity

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. 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.

Additional details about this process are included in **Section 5**.

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 2** 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 2**, the majority of Brevard County is located in Zone A of the Central IRL watershed, and achieving reductions in this portion of the Central IRL is the focus of this plan. A portion of the County is also located in Zone SEB. However, 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 are more than enough to meet the required reductions in the Brevard County portion of Zone SEB, as shown in **Table 2**.

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.

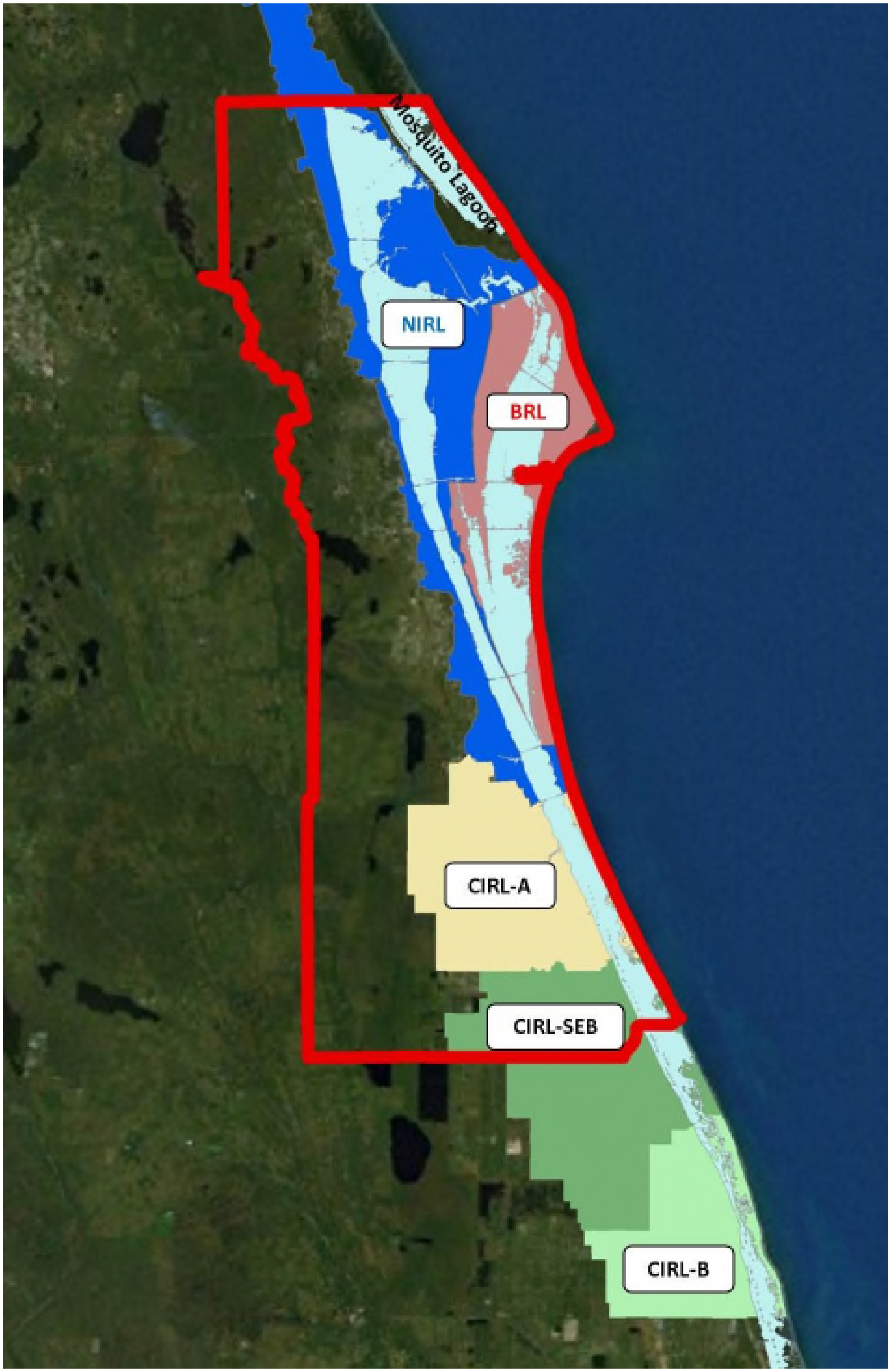


Figure 2: Locations of the Banana River Lagoon (BRL), North IRL (NIRL), and Central IRL (CIRL) Sub-Lagoons

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 on impervious areas associated with urban development. Urban runoff picks up and transports nutrient loading from fertilizers and pet waste, as well as other pollutants including sediments, pesticides, oil, and grease.
  - 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, 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.
- 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.

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 3, Figure 4**, and **Figure 5**.

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*	452,000	68,400	660,000	99,000	170,000	25,000

*Muck flux values were calculated with two significant figures.

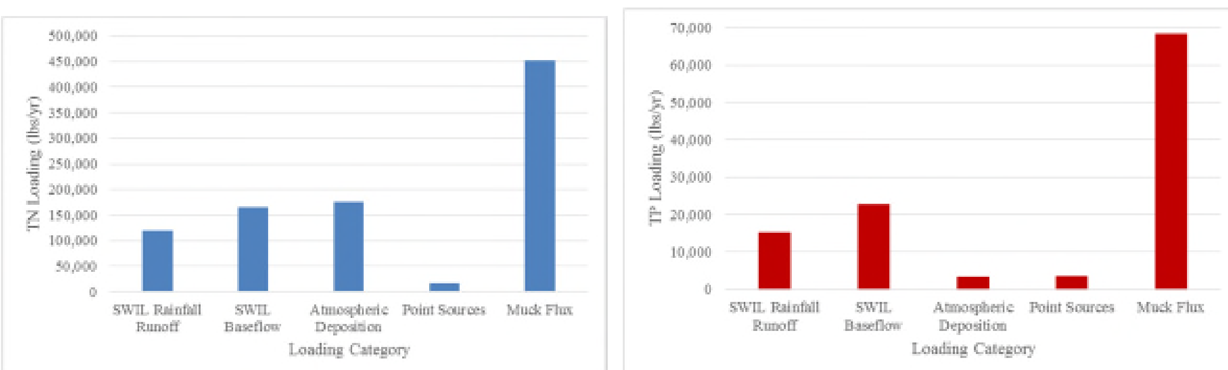


Figure 3: Banana River Lagoon TN (left) and TP (right) Annual Average Loads by Source

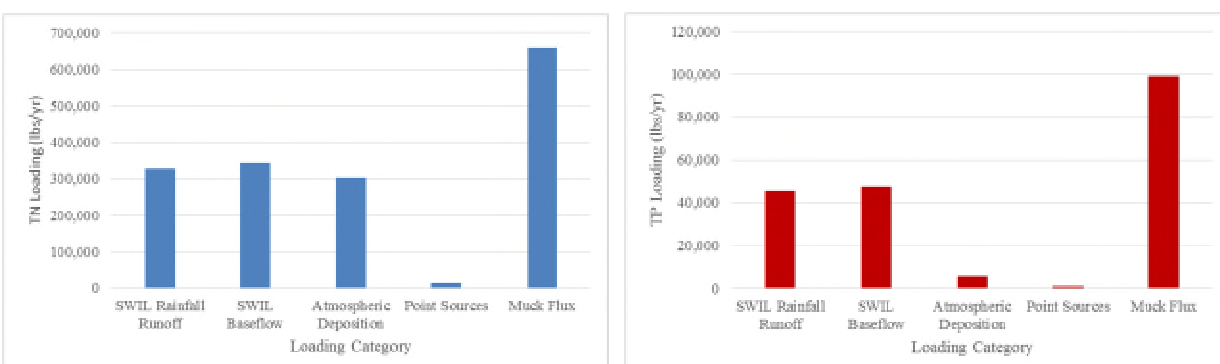


Figure 4: North IRL TN (left) and TP (right) Annual Average Loads by Source

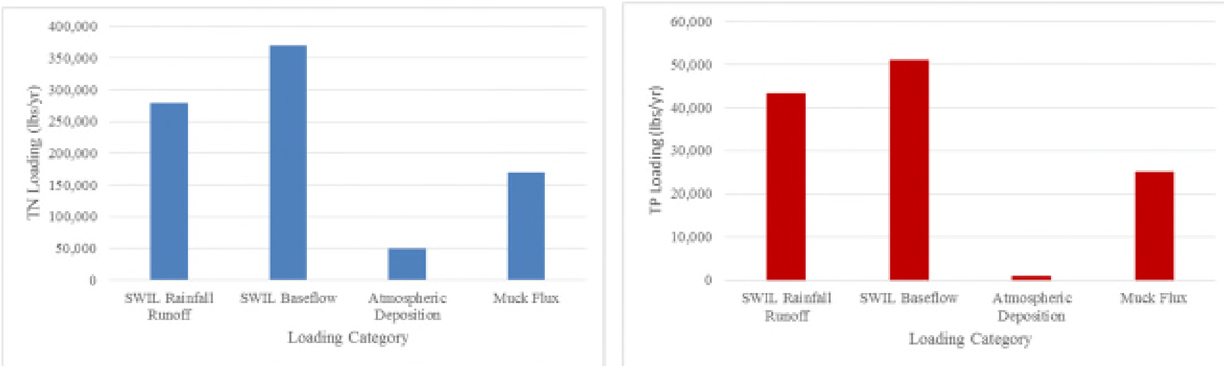


Figure 5: Central IRL TN (left) and TP (right) Annual Average Loads by Source

Section 4 includes projects to reduce the loading from urban stormwater runoff (including fertilizers), 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 Science Technology and Economic Adaptive Management (STEAM) Team (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 6** 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 Fertilizer Management and Public Outreach and Education

Fertilizer in Brevard County

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 6** summarize the nutrients in the lawn fertilizer sold in Brevard County, according to FDACS records. This information was organized by growing year (June 1 – May 31); however, one month of data was missing from the first growing year and two months of data were missing from the last growing year. These figures show 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 Growing Year (June 1 – May 31)

Growing Year	Lawn Fertilizer Nitrogen (tons/yr)	Lawn Fertilizer Nitrogen (lbs/yr)	Lawn Fertilizer Phosphorus (tons/yr)	Lawn Fertilizer Phosphorus (lbs/yr)
July 2012 - May 2013	1,653	3,306,435	60	120,193
June 2013 - May 2014	329	657,470	64	127,770
June 2014 - May 2015	178	356,350	11	21,870
June 2015 - March 2016	235	470,737	27	54,211

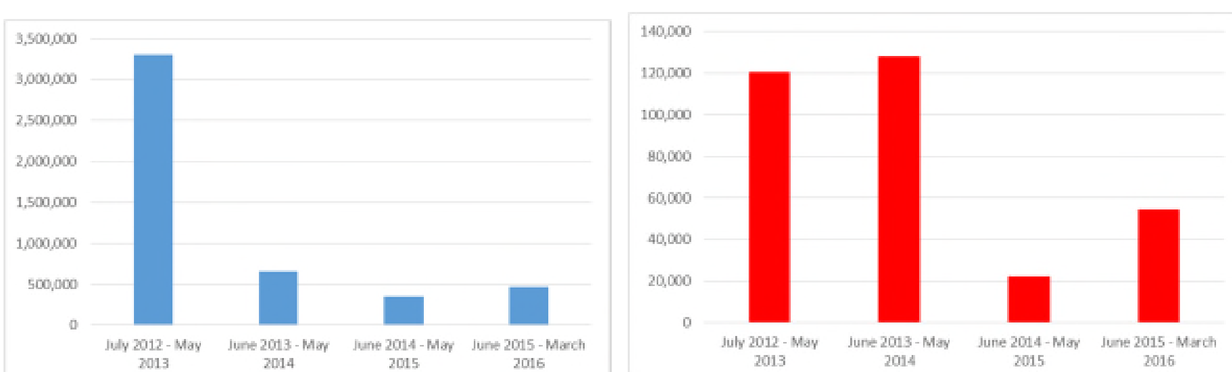


Figure 6: TN (left) and TP (right) in Lawn Fertilizer Sold in Brevard County by Growing Year

Fertilizer Ordinance

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.

Blue Life Education and Outreach

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 7**), radio advertisements, *Florida Today* sticky note (see **Figure 8**), and water bill insert for the City of Cocoa and City of Melbourne customers.

Figure 7: New Blue Life Digital Billboard

Figure 8: *Florida Today* Sticky Note

University of Florida (UF) Institute of Food and Agricultural Sciences (IFAS) Extension Brevard County Public Education and Outreach

The UF-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 on site 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 turf grass 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 turf grass 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 is a new program for 2016. The target audience is property managers, realtors, homeowner/condominium association boards, and developers. This program will educate the participants about BMPs for lawns and ponds.

Retail Garden Center Employee Education – This is a new program for 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^{SM} 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.

Estimated Reductions from Lawn Fertilizer Management and Public Education

Based on the FDACS information, the lawn fertilizer sold in the 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 of 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.

4.1.2 WWTF 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 9 mg/L is optimal for turf grass 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 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 TN concentrations greater than 9 mg/L are listed in **Table 9**. This table also summarizes the excess TN in the reclaimed water after attenuation (60% for TN [FDEP 2014b]), 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).

Table 9: WWTFs with Excess TN in the 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)
Barefoot Bay Water Reclamation Facility (WRF)	0.9	0.48	11.9	7,073	3,566
North Regional WWTF	0.9	0.26	11.4	3,670	1,932
Port St. John WWTF	0.5	0.35	10.7	4,638	2,601
City of Melbourne Grant Street WWTF	5.5	0.22	11.5	3,133	1,635
City of Palm Bay WRF	4.0	0.656	29.4	23,883	6,093
City of Titusville Osprey WWTF	2.75	1.56	17.9	34,579	11,591
City of West Melbourne Ray Bullard WRF	2.5	0.85	11.1	11,684	6,316

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 10**. 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 10: 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	17,790	$79
City of Titusville Osprey WWTF	$8,000,000	22,988	$348
City of West Melbourne Ray Bullard WRF	$6,000,000	5,368	$1,118
Barefoot Bay WRF	$6,000,000	3,507	$1,711
North Regional WWTF	$6,000,000	1,739	$3,451
Port St. John WWTF	$6,000,000	2,037	$2,946
City of Melbourne Grant Street WWTF	$6,000,000	1,498	$4,004

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

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 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 11**). 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 11: 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 14**, 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 12**). The estimated travel times based on the distance from the septic system to a waterbody are shown in **Table 13**, 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 12** and the travel times in **Table 13**. The concentrations used in the estimates for this plan are shown in **Table 14**.

Table 12: 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 13: 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 14: 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 15**). Therefore, this plan focuses on the locations where reductions through septic system removal are the most cost-effective.

Table 15: 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 those lots that only require limited extensions of infrastructure from existing service areas to connect to sewer service. 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 16** for the Banana River Lagoon, **Table 17** for the North IRL, and **Table 18** for the Central IRL. **Appendix A** 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 16: 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 17: 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 18: 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 19: 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	1,093	$16,684,000	28,744	$746
Total	***2,347***	***$41,764,000***	***56,509***	***$840***

There are also areas identified for long-term septic system connection opportunities, which are listed in **Table 20**. 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 20: 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. 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. The estimated cost per connection is $6,000 to $10,000, which includes the cost of the pipes. The customers also must maintain the STEP system and pay the electrical costs to operate the pump for this system.

For properties within 55 yards of a waterbody and located immediately adjacent to a pressure line, the STEP system may be a good option instead of the septic system upgrades described below. Additional analyses and field inspections are needed to determine where these systems are most feasible without causing right-of-way conflicts or infrastructure issues. If STEP systems are selected as a preferred option in the future, this plan can be updated with information on the sub-lagoon location of those systems, costs, and estimated benefits.

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.

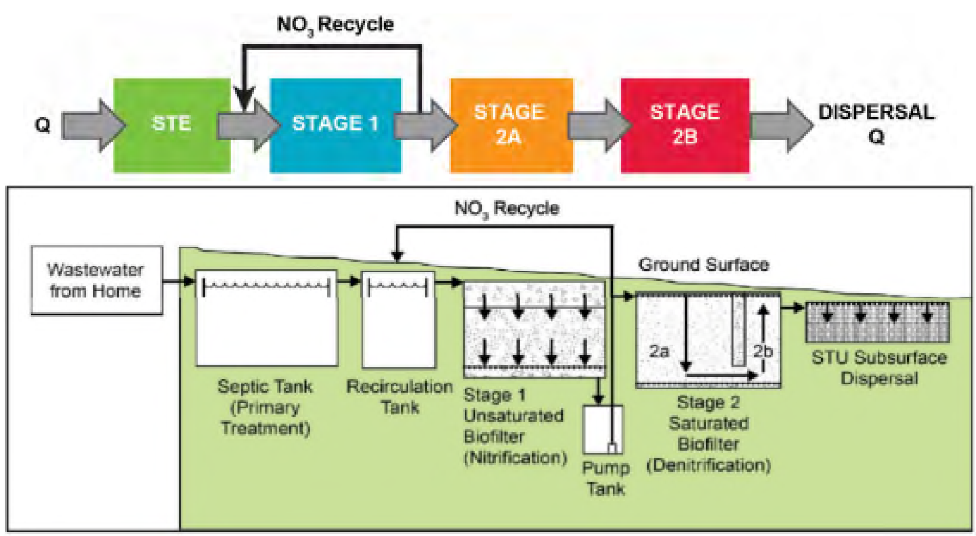
One option for a septic system upgrade is to add a biosorption activated media (BAM) to enhance nutrient and bacterial removal before the effluent reaches the drainfield or groundwater. Examples of BAM include mixes of soil, sawdust, zeolites, tire crumb, vegetation, sulfur, and spodosols (Wanielista 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 9.**

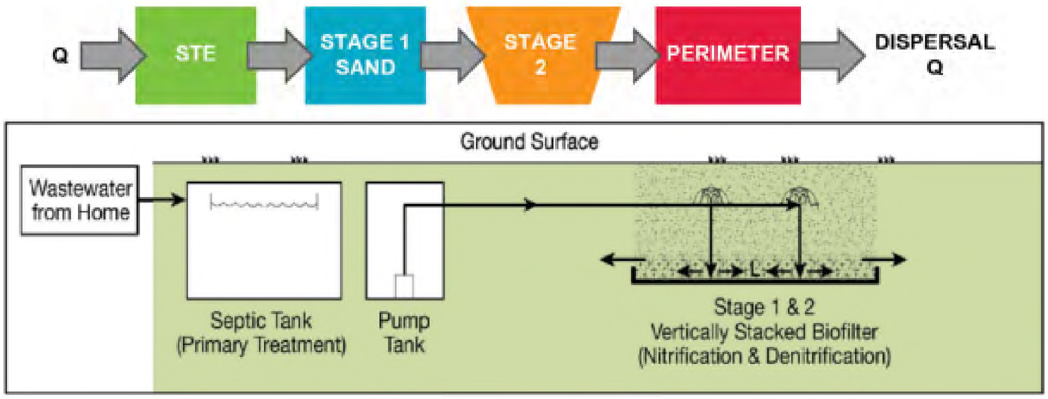


Note: from Hazen and Sawyer 2015

Figure 9: 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 10**.



Note: from Hazen and Sawyer 2015

Figure 10: 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. 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 21**. The results of this scoring provided information used to prioritize septic systems for upgrades.

Table 21: Summary of Septic System Scoring Criteria

Evaluation Factors	Scores	Explanation
A - Groundwater Table (GWT)	0 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."
	8 points: GWT = 48 inches	
	12 points: GWT < 48 inches	
B - Soil Types	0 points: Most ideal soils for drainfield performance	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 example from Martin County.
	8 points: Moderate drainfield performance	
	12 points: Excessively or poorly drained soils	
C - Surface Water Management Systems	4 points: Property developed after 1986	These scores were derived by joining the property appraiser data to the scoring table and scoring based on the year built field.
	8 points: Property developed between 1980 and 1986	
	12 points: Property developed before 1980	
D - Population Density	4 points: Low Density < 2 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).
	8 points: Medium Density > 2-5 units per acre	
	12 points: High Density > 5 units per acre	
E - Proximity to Surface Waters	4 points: Properties greater than 219 yards from an open channel	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.
	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	

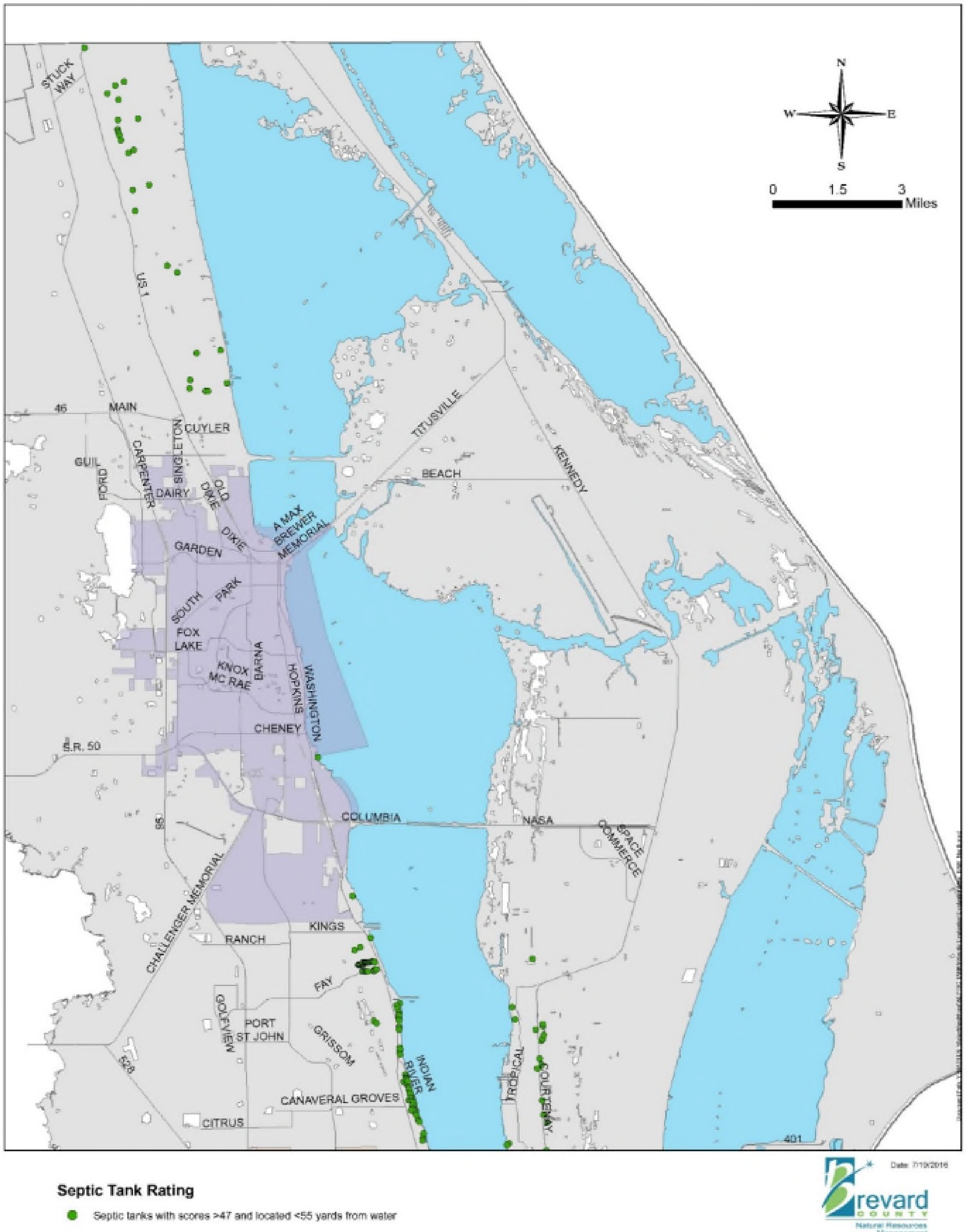
The septic systems with the highest (worst) scores and within 55 yards of a surface waterbody are recommended for retrofit upgrades to reduce the impacts of these septic systems on the waterbodies. The number of these lots and the costs by sub-lagoon are shown in **Table 22**. The locations of these septic system upgrades are shown in **Figure 11**, **Figure 12**, and **Figure 13**. This upgrade opportunity addresses 2.3% of the septic systems in the IRL drainage basin.

Table 22: 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***

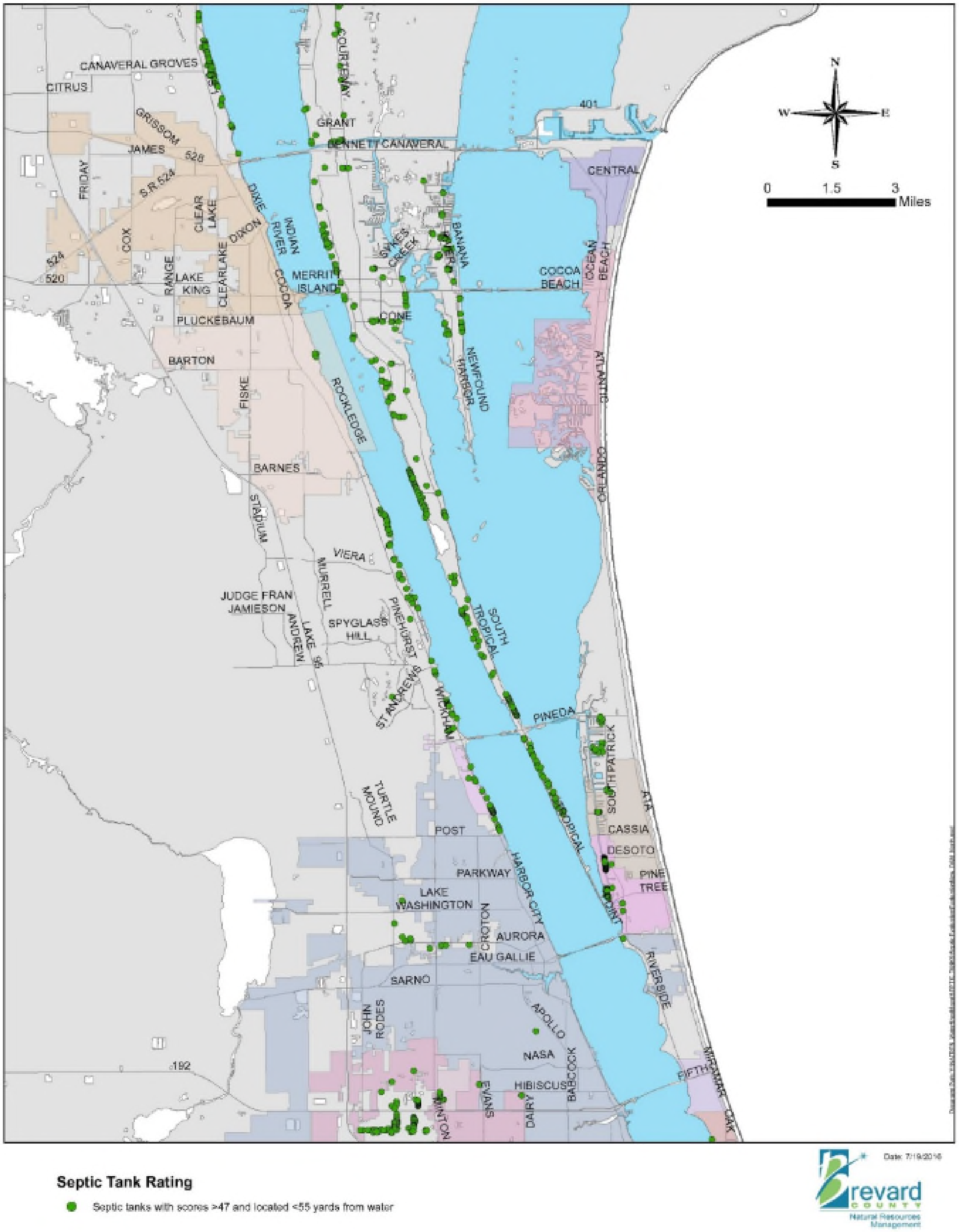
Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

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.



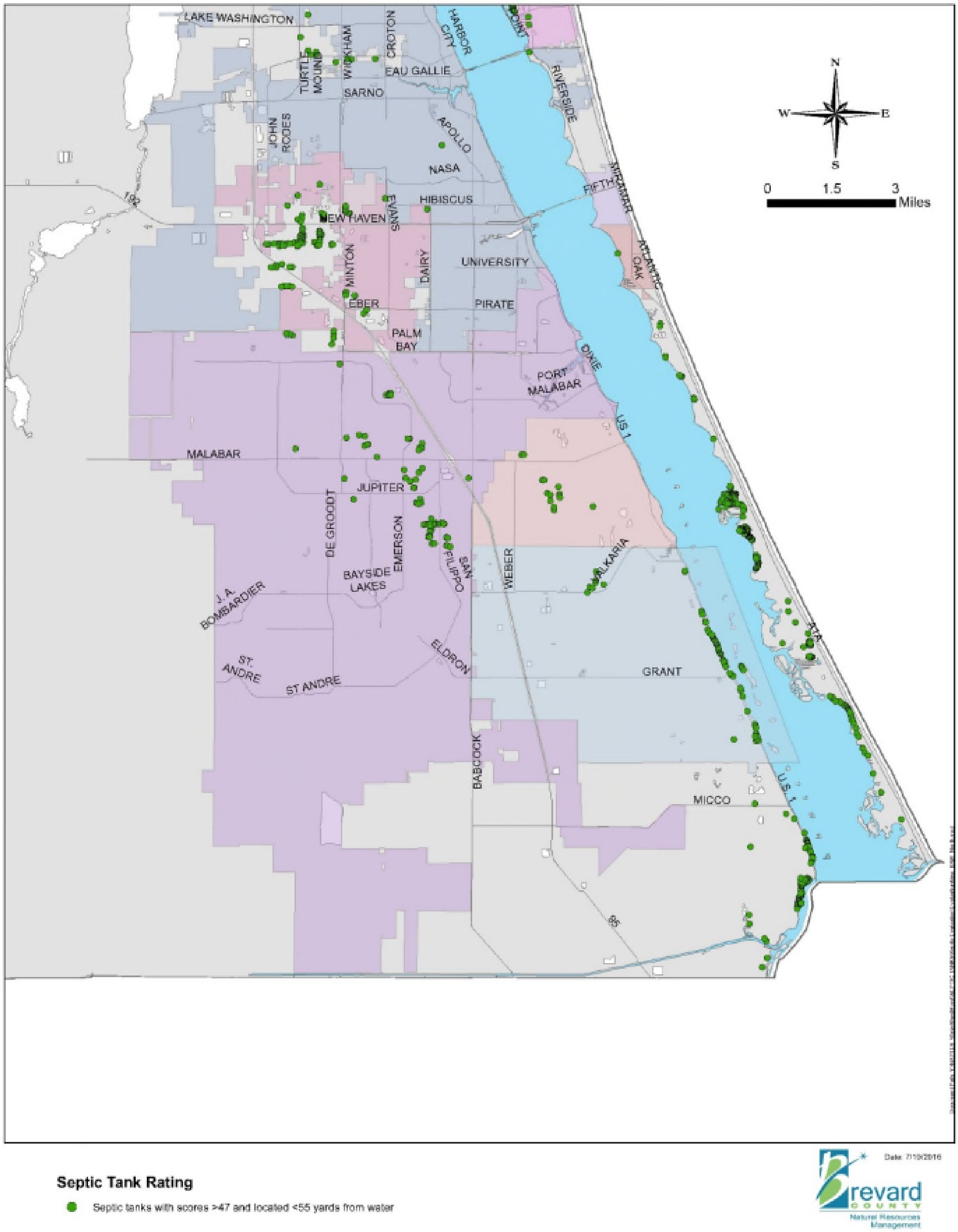
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time. County staff removed nearly 10,000 locations from FDOH maps based on confirmation data from municipalities for specific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

Figure 11: 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 12: 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 13: Map of Locations for Septic System Upgrades in Central IRL

4.1.4 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 23**.
- 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 24**.
- 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 23: 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 ground water 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 ground water 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
2^{nd} 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 24: 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 2014a
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 2014a
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 2014a
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 2014a).	38%-65%	50%-80%	FDEP 2014a

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 25**.

Table 25: 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 the highest priority outfalls in each sub-lagoon are shown in **Table 26**, as well as the estimated cost per pound of TN or TP removed. A detailed list of stormwater projects is included in **Appendix B**. The locations of the basins to be treated are shown in **Figure 14**, **Figure 15**, and **Figure 16**.

Table 26: 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	6	$1,325,000	17,113	$77	2,497	$531

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

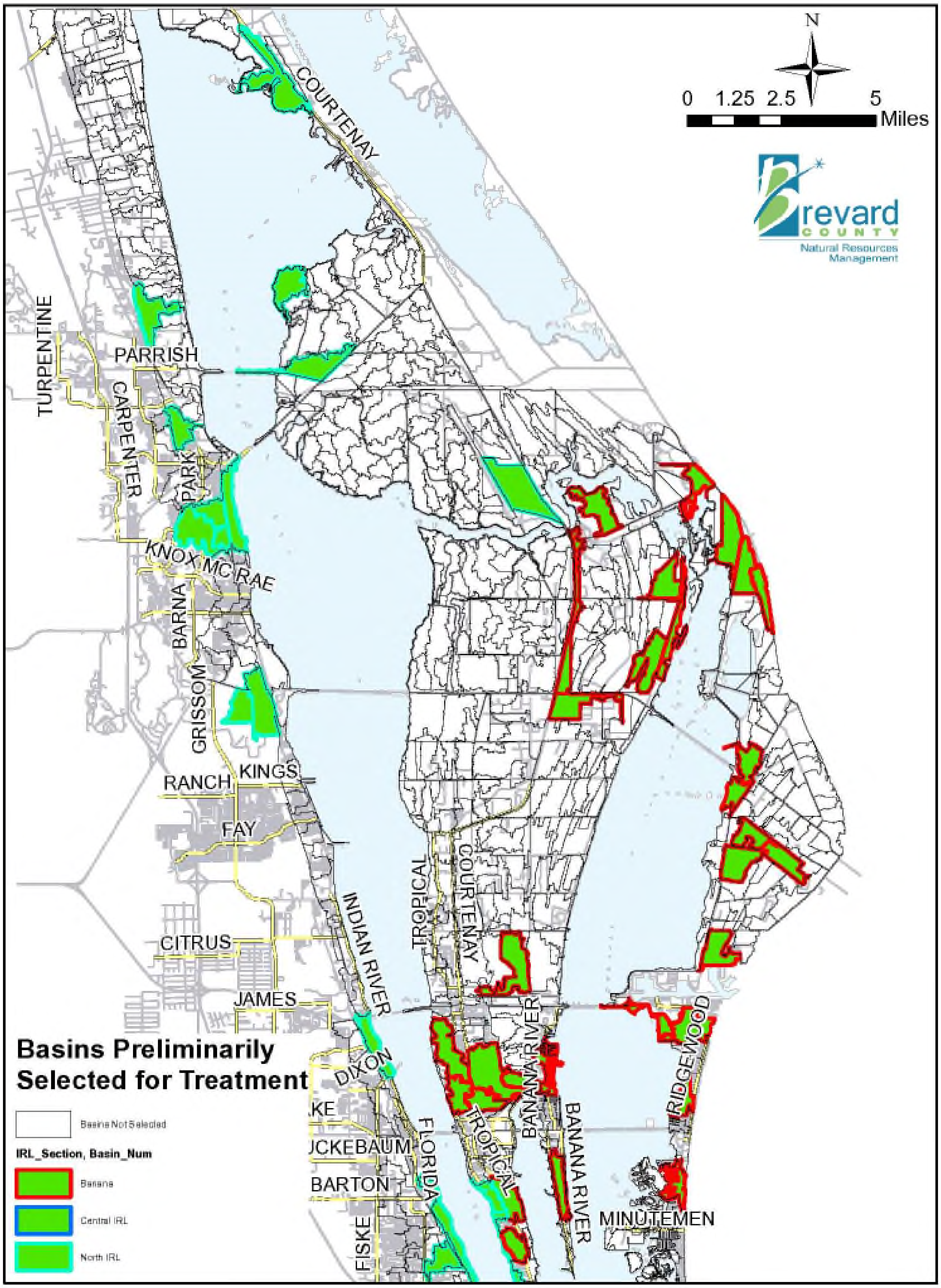


Figure 14: Map of Selected Stormwater Projects in Banana River Lagoon and North IRL

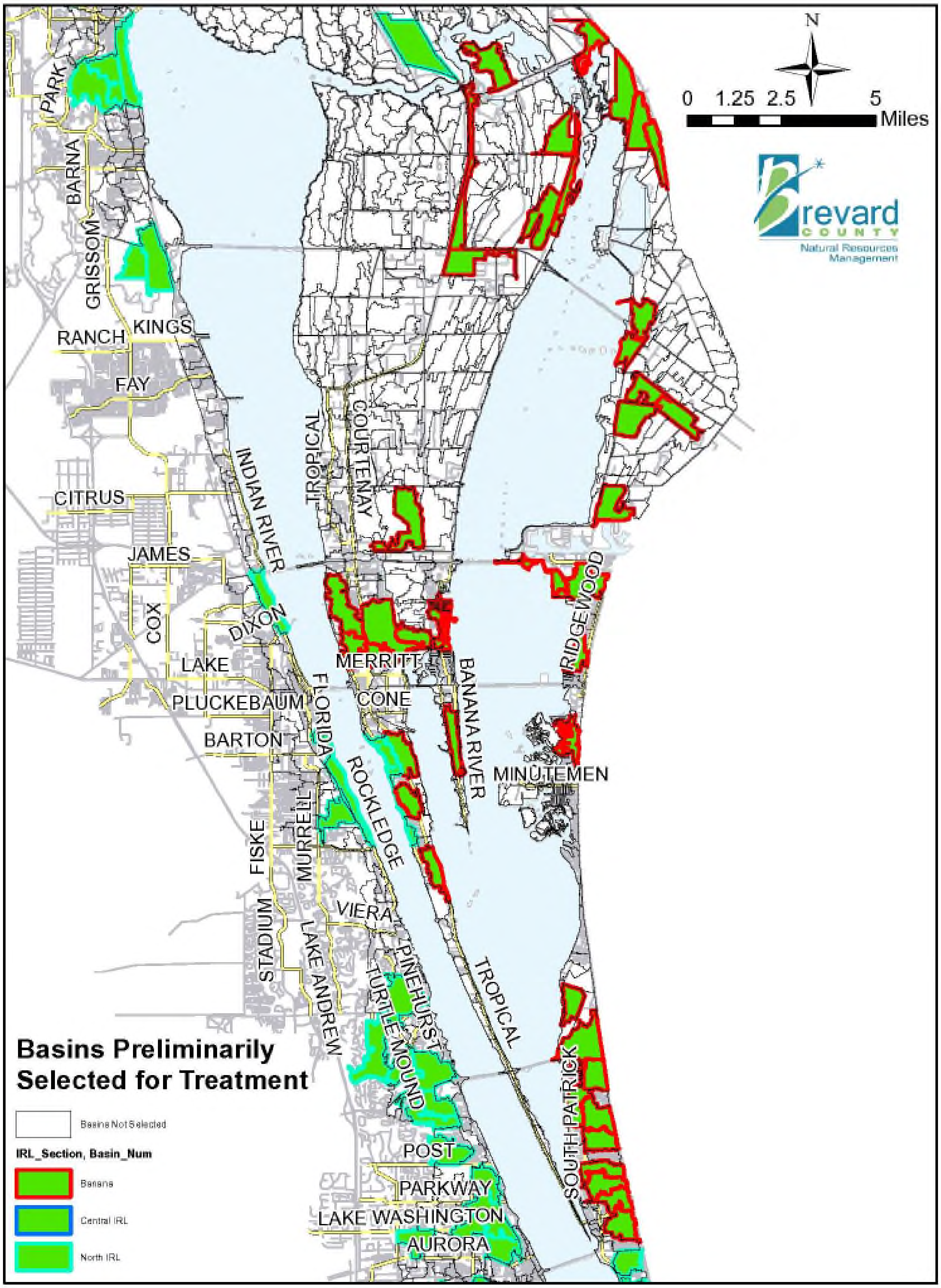


Figure 15: Map of Selected Stormwater Projects in Banana River Lagoon and North IRL, continued

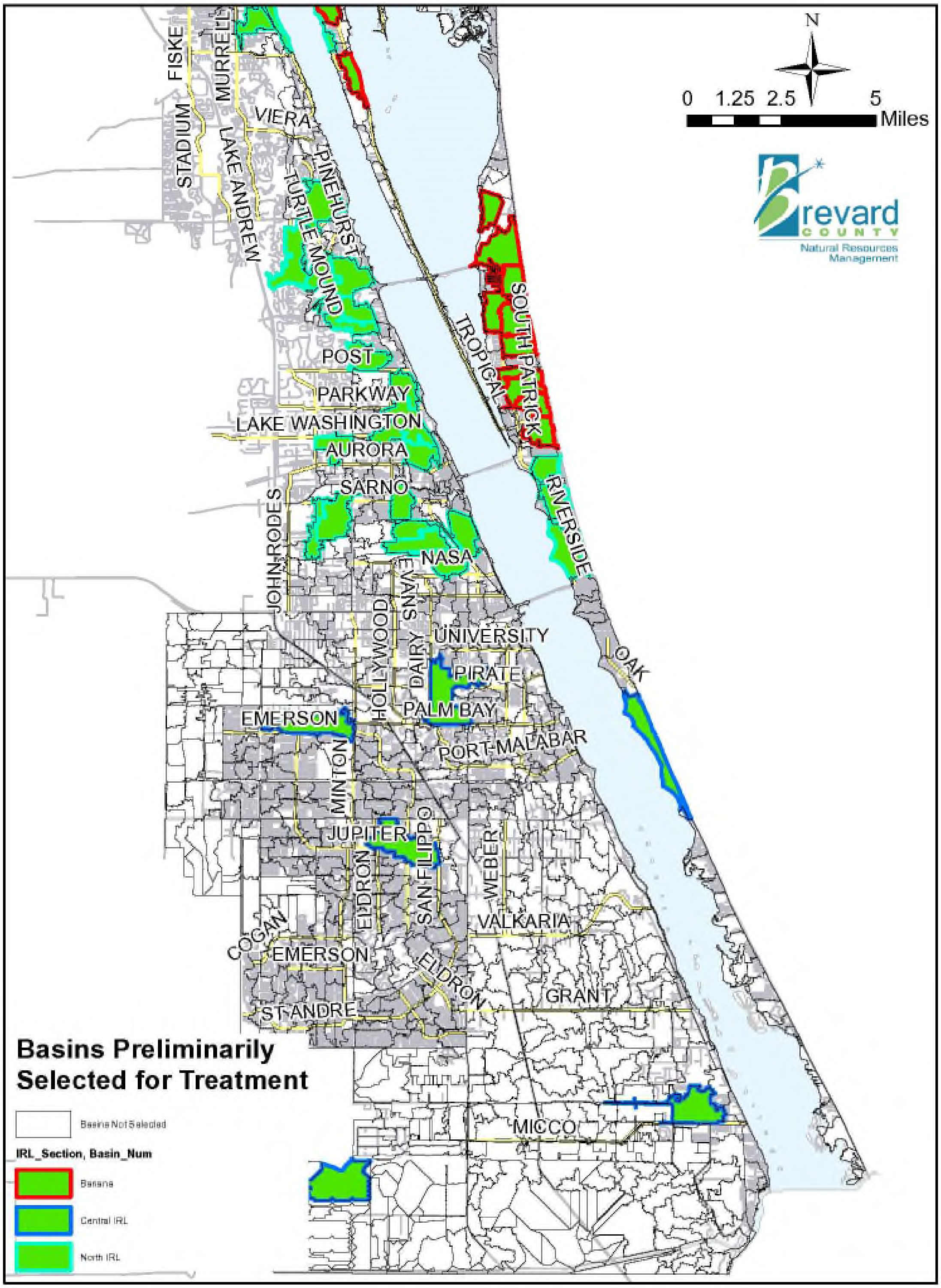


Figure 16: Map of Selected Stormwater Projects in North IRL and Central IRL

4.1.5 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 $16,034,000 for design, permitting, and construction. The cost to operate and maintain the remediation facility is estimated to be $4,020,000 per year. **Table 27** summarizes the benefits and the costs of nutrient removal for this project for a 10-year period.

Table 27: 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
$48,194,000	35,633	2,132	$1,353	$22,605

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 3**, 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 9 pounds of TN/yr/acre and 1.3 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 28**.

Table 28: 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 muck dredging projects are shown in **Table 29** for the Mosquito Lagoon, **Table 30** for the North IRL, **Table 31** for the Banana River Lagoon, and **Table 32**. The locations of these projects are shown in **Figure 17** and **Figure 18**. The total costs of these projects is $182 million. Using the flux rates noted above, 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 33**).

Table 29: Mosquito Lagoon Estimated Costs for the Proposed Muck Removal Projects

Location	Muck Area (acres)	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Near Haulover Canal	568	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 30: North IRL Estimated Costs for Proposed Muck Removal Projects

Location	Muck Area (acres)	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Titusville Area	371	260	400,000	$14,000,000
Cocoa Area	494	346	600,000	$21,000,000
Rockledge Area	741	519	800,000	$28,000,000
Eau Gallie Area	988	692	750,000	$26,250,000
North IRL Total	***2,594***	***1,817***	***2,550,000***	***$89,250,000***

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

Table 31: Banana River Lagoon Estimated Costs for the Proposed Muck Removal Projects

Location	Muck Area (acres)	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Cape Canaveral Area	988	692	750,000	$26,250,000
Cocoa Beach Area	247	173	200,000	$7,000,000
Newfound Harbor Area	124	87	100,000	$3,500,000
Pineda Causeway Area	124	87	100,000	$3,500,000
Mathers Bridge Area	185	130	150,000	$5,250,000
Venetian Collector Canals/Channels	470	170	750,000	$26,250,000
Banana River Total	***2,138***	***1,339***	***2,050,000***	***$71,750,000***

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

Table 32: Central IRL Estimated Costs for the Proposed Muck Removal Projects

Location	Muck Area (acres)	Dredge Area (acres)	Muck Volume (cubic yards)	Dredging Cost Estimate
Melbourne Causeway Area	173	121	200,000	$7,000,000
Goat Creek Area	124	87	100,000	$3,500,000
Trout Creek Area	124	87	100,000	$3,500,000
Mullet Creek Islands Area	247	173	200,000	$7,000,000
Central IRL Total	***668***	***467***	***600,000***	***$21,000,000***

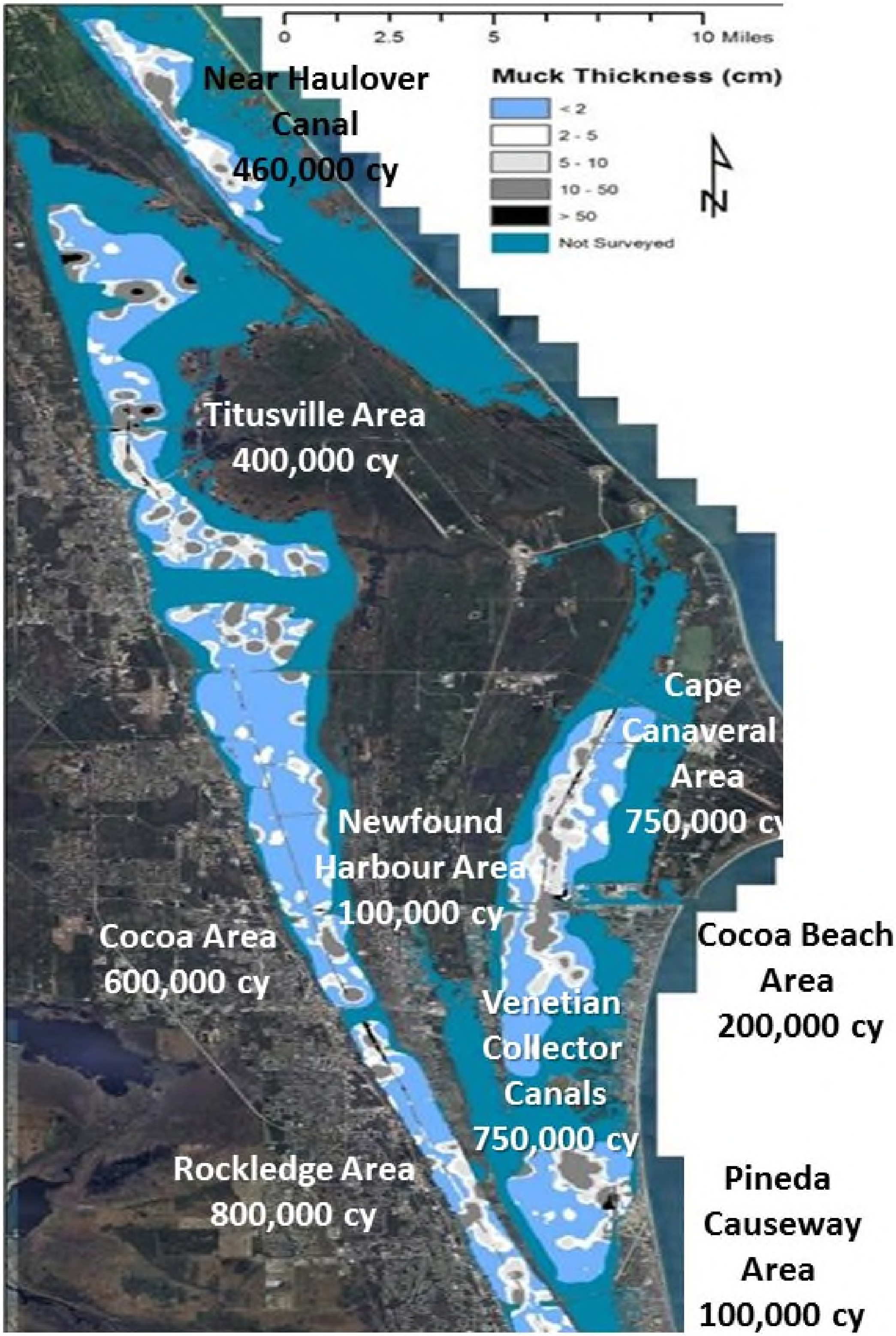
Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

Table 33: Nitrogen and Phosphorus Reductions from Muck Removal

Location	TN Flux Reduction (lbs/yr)	Project Cost	Cost/lb/yr of TN Removed	TP Flux Reduction (lbs/yr)	Cost/lb/yr of TP Removed
Mosquito Lagoon	35,000	$16,100,000	$460	5,250	$3,067
North IRL	231,500	$89,250,000	$386	34,700	$2,572
Banana River Lagoon	165,300	$71,750,000	$434	24,800	$2,893
Central IRL	59,500	$21,000,000	$353	8,900	$2,400

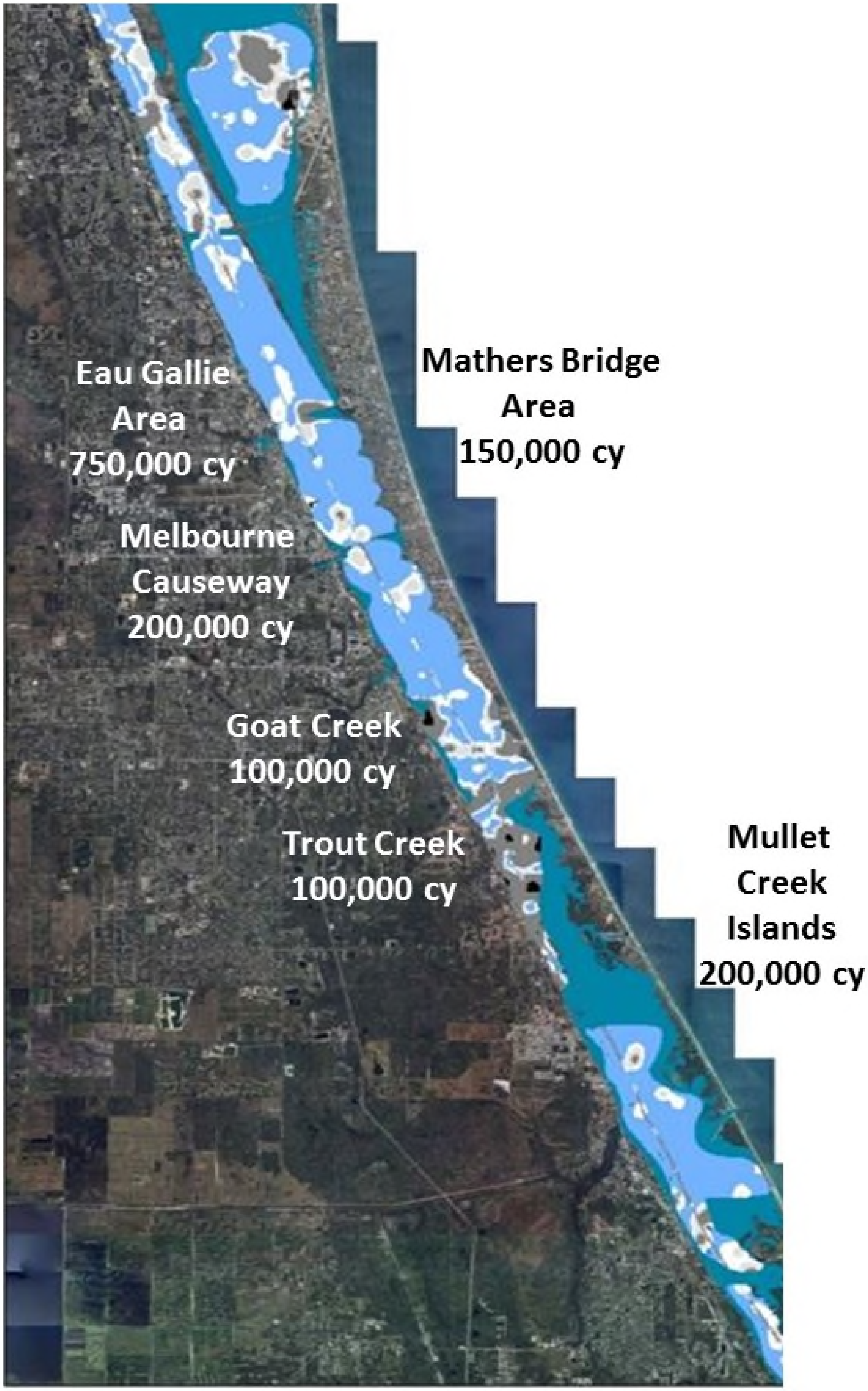
Note: The projects highlighted in green are the most cost-effective and are recommended as part of this plan.

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



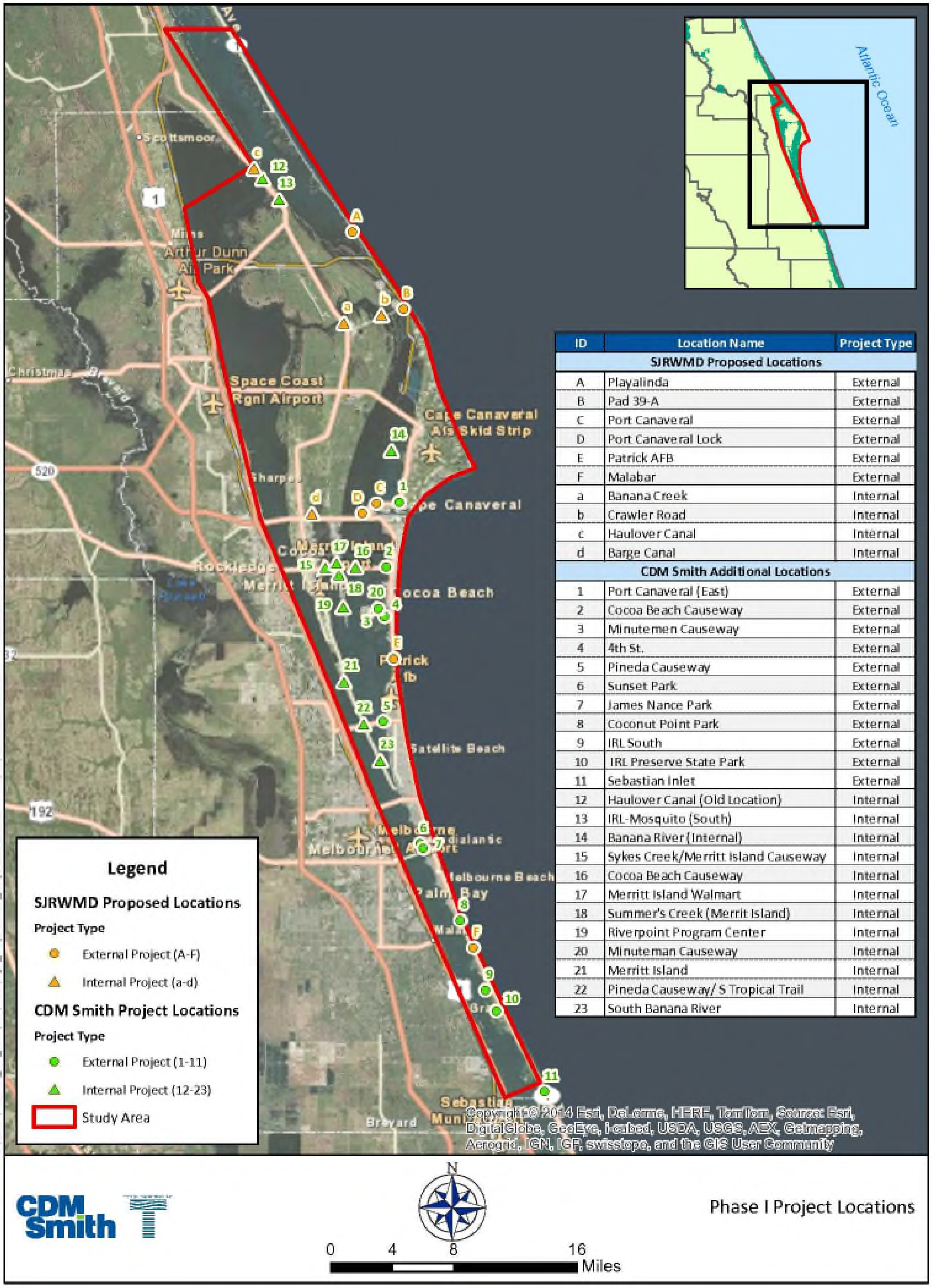
Note: Map is from SJRWMD for informational purposes only and is based on data from 2014. Annotation of project areas by County staff working with muck research scientists.

Figure 18: Location of Potential Muck Removal Projects in North IRL and Central IRL

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 19**. From this first phase, ten locations were identified for future evaluation as shown in **Table 34**. 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).



ID	Location Name	Project Type
	SJRWMD Proposed Locations	
A	Playalinda	External
B	Pad 39-A	External
C	Port Canaveral	External
D	Port Canaveral Lock	External
E	Patrick AFB	External
F	Malabar	External
a	Banana Creek	Internal
b	Crawler Road	Internal
c	Haulover Canal	Internal
d	Barge Canal	Internal
	CDM Smith Additional Locations	
1	Port Canaveral (East)	External
2	Cocoa Beach Causeway	External
3	Minutemen Causeway	External
4	4th St.	External
5	Pineda Causeway	External
6	Sunset Park	External
7	James Nance Park	External
8	Coconut Point Park	External
9	IRL South	External
10	IRL Preserve State Park	External
11	Sebastian Inlet	External
12	Haulover Canal (Old Location)	Internal
13	IRL-Mosquito (South)	Internal
14	Banana River (Internal)	Internal
15	Sykes Creek/Merritt Island Causeway	Internal
16	Cocoa Beach Causeway	Internal
17	Merritt Island Walmart	Internal
18	Summer's Creek (Merrit Island)	Internal
19	Riverpoint Program Center	Internal
20	Minuteman Causeway	Internal
21	Merritt Island	Internal
22	Pineda Causeway/ S Tropical Trail	Internal
23	South Banana River	Internal

Source: CDM Smith et. al., 2015.

Figure 19: Phase I Potential Artificial Flushing Project Locations

Table 34: 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 34**. 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 35**):

- 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 35: 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 moving out of the port after the lock was held open for an extended period of time. In addition, there are limited data on 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.

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).

Brevard County

The focus for oyster restoration in the IRL system is to provide 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 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 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 and the pilot study will be completed in fall 2016. The final design of future sites will be determined based on monitoring results from the pilot reefs and wave tank studies to test reef stability and wave attenuation.

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 36**, 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 of oysters in the IRL system will likely be greater than those estimated here.

Table 36: 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 37**).

Table 37: 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.

4.4. Respond

The funding raised from the Save Our Lagoon referendum 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 on projects implemented and adjustments to the proposed projects. A volunteer team of diversely skilled citizens will be assembled to assist the County with the annual plan updates. Team members will represent the fields of Science, Technology, and Economics for Adaptive Management (STEAM). Two to three appointments to the STEAM Team will be made by each member of the authority that collects the Save Our Lagoon revenues, whether is it the Brevard County Board of County Commissioners or a special district. STEAM Team appointees will also represent municipalities, lagoon advocacy organizations, tourism, and real estate interests. Appointees will serve for a two-year term, after which time they may be considered for reappointment or replacement. The Team's recommendations will be presented annually to the authority that collects the revenues, and changes to the plan will be approved by that authority.

Brevard County staff will provide project monitoring reports to the STEAM Team 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 STEAM Team for inclusion in the next annual update to this plan. Projects that deliver comparable nutrient removal benefits may be substituted for listed projects in the same sub-lagoon in exchange for the allocated funds. If a substituted project costs more than the project listed in this plan, the requesting partner would have to 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 ground water load contribution data and conduct ground water 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.
    - Continue projects related to monitoring the resources of the IRL and address gaps in data as needed.
    - Identify, inventory and assess finfish and shellfish habitats within the IRL and implement appropriate management and restoration strategies.
    - Develop a coordinated fisheries research agenda to improve the present knowledge of the fisheries in the IRL.
    - Support and expand research initiatives and coordinated finfish and shellfish management strategies specific to the IRL.
    - Support the inventory and assessment of non-native invasive fauna and flora within the IRL basin.
    - 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.
    - Undertake studies of wildlife diseases occurring in the IRL region, which may be caused by human activities.
    - Track state, national and international actions and research concerning climate change issues that affect the IRL.
    - Support IRL-based research that considers and integrates global climate change issues and seeks practical scientific, technological and public policy solutions.
    - Undertake research to develop new and improved wetland management BMPs.
    - Monitor boating impacts to IRL natural resources. Where appropriate, establish resource protection zones and monitor their effectiveness.

Section 5. Maximizing Benefits and Managing Risk

In order to maximize the benefits for every dollar spent on restoration and minimize the unavoidable risks inherent with repairing a complex system such as the IRL that has been damaged by decades of human impact, the County applied rigorous decision science to select projects that would be most effective and to sequence those projects into a multi-year plan. Top scientists in the region, tourism experts, fisheries experts, civic leaders, environmentalists, and property value experts knowledgeable about the IRL and Brevard County were consulted as part the process to develop this projects plan.

This effort has resulted in a plan that maximizes both the return on investment for taxpayer funds, as well as the likelihood that a healthy lagoon will be restored as quickly as possible with the funds made available.

5.1. 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 20 represents the input from the Subject Matter Experts.

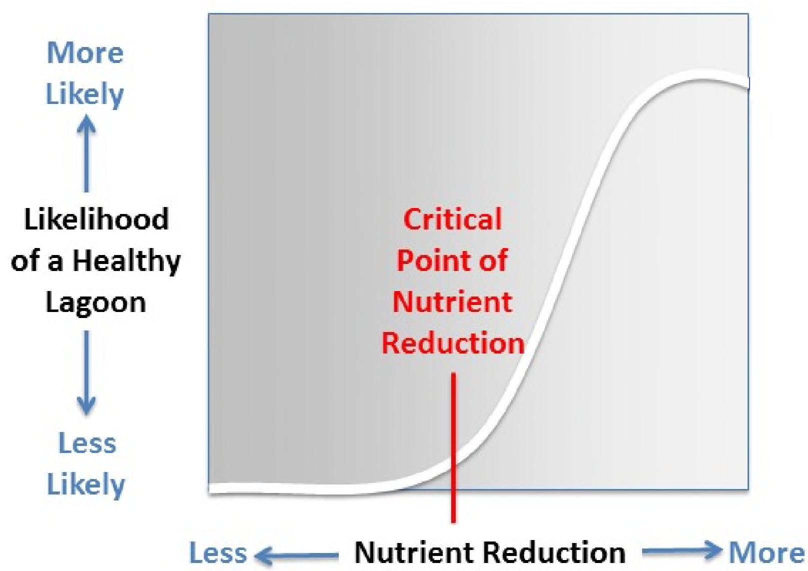


Figure 20: Likelihood of a Healthy IRL as Nutrients are Removed

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 6. Summary of the Plan

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. Based on this process, five-month TMDLs, which target the load reductions needed during the seagrass growing period (January – May), were determined. These load reductions specifically target water quality conditions needed for restoring lagoon seagrass beds in order to provide crucial habitat for fish and other marine life. Therefore, as this Save Our Lagoon Project Plan was developed, the TN and TP reductions from the proposed projects 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, monitoring will occur throughout the year to track progress toward the five-month and full-year TMDLs.

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) were included in the load reduction calculations as these projects provide nutrient load reductions in addition to those listed in the plan. In Zone A of the Central IRL, the reductions from SJRWMD's C-1 re-diversion project, which is being implemented with cost-share funding from FDEP and Brevard County, were also included as this project will result in significant load reductions. As shown in **Table 38**, **Table 40**, and **Table 42**, the projects proposed in this plan plus the recently completed BMAP projects and C-1 re-diversion project exceed the TMDL five-month reductions.

The total project reductions were also compared to the full year estimated loading to the lagoon from the SWIL model. As shown in **Table 39**, **Table 41**, and **Table 43**, 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.

Table 38: 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 Fertilizer Education	393	52
Septic System Removal	5,723	0
Septic System Upgrade	2,144	0
Stormwater Projects	13,867	2,257
BMAP Projects (2010-February 2016)	5,303	1,440
Total	***30,375***	***4,352***
TMDL Reductions (five-month)	***30,337***	***2,737***
% of TMDL Reductions Achieved	***100.1%***	***159.0%***

Table 39: 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 Fertilizer Education	943	125
Septic System Removal	13,736	0
Septic System Upgrade	5,145	0
Stormwater Projects	48,391	6,977
BMAP Projects (2010-February 2016)	12,726	3,456
Total	***88,009***	***12,004***
Starting Load (full year)	***477,020***	***44,269***
% of Starting Load Reduced	***18.4%***	***27.1%***
Full-Year TMDL % Reductions	***9.0%***	***9.6%***

Table 40: 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 Fertilizer Education	1,077	143
WWTF Upgrade for Reclaimed Water	9,578	TBD
Septic System Removal	5,845	0
Septic System Upgrade	4,279	0
Stormwater Projects	15,622	2,542
BMAP Projects (2010-February 2016)	16,983	3,180
Total	***61,454***	***7,516***
TMDL Reductions (five-month)	***61,447***	***7,410***
% of TMDL Reductions Achieved	***100.0%***	***101.4%***

Table 41: 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 Fertilizer Education	2,584	343
WWTF Upgrade for Reclaimed Water	22,988	TBD
Septic System Removal	14,029	0
Septic System Upgrade	10,270	0
Stormwater Projects	52,936	7,567
BMAP Projects (2010-February 2016)	40,758	7,632
Total	***162,933***	***19,504***
Starting Load (full year)	***988,847***	***99,340***
% of Starting Load Reduced	***16.5%***	***19.6%***
Full-Year TMDL % Reductions	***11.4%***	***11.4%***

Table 42: 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 Fertilizer Education	1,082	144
WWTF Upgrade for Reclaimed Water	7,413	TBD
Septic System Removal	11,977	0
Septic System Upgrade	5,102	0
Stormwater Projects	5,116	833
C-1 Re-Diversion	53,892	6,295
BMAP Projects (2010-February 2016)	378	243
Total	***93,068***	***9,174***
TMDL Reductions (five-month)	***67,547***	***8,151***
% of TMDL Reductions Achieved	***137.8%***	***112.6%***

Table 43: 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 Fertilizer Education	2,596	345
WWTF Upgrade for Reclaimed Water	17,790	TBD
Septic System Removal	28,744	0
Septic System Upgrade	12,244	0
Stormwater Projects	17,113	2,497
C-1 Re-Diversion	129,341	15,108
BMAP Projects (2010-February 2016)	908	582
Total	***228,196***	***22,513***
Starting Load (full year)	***698,937***	***95,051***
% of Starting Load Reduced	***32.6%***	***23.7%***
Full-Year TMDL % Reductions	***22.9%***	***21.5%***

In addition to the projects that address the external nutrient loading summarized above, the plan includes muck removal and oyster reef living shoreline projects that will address internal nutrient loading within the lagoon itself. The reductions from the muck removal and oyster reef projects are summarized in **Table 44**, along with the percentage of nutrients from muck flux that would be reduced by these projects.

Table 44: Muck Removal and Oyster Reef Project Reductions Compared to Nutrients 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	165,300	24,800	231,500	34,700	59,500	8,900
Oyster Reef Living Shoreline Reductions	N/A	N/A	8,934	3,038	9,124	3,102	3,062	1,041
Total Project Reductions	35,000	5,250	174,234	27,838	240,624	37,802	62,562	9,941
Estimated Muck Flux Loading	97,400	14,600	452,000	68,400	660,000	99,000	170,000	25,000
% of Muck Flux Reduced	***35.9%***	***36.0%***	***38.5%***	***40.7%***	***36.5%***	***38.2%***	***36.8%***	***39.8%***

Table 45 summarizes the projects, 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 46**). Projects that could achieve large reductions quickly, such as fertilizer reductions and WWTF upgrades, as well as the most cost-effective stormwater projects were prioritized for implementation. This prioritization allows for the reductions to occur as quickly as possible while best using available funding sources. The timeline in **Table 46** is shown in years after funding from the Save Our Lagoon referendum becomes available.

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 45: 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
Fertilizer Management/Public Education	$625,000	6,123	$102	813	$769
WWTF Upgrades for Reclaimed Water	-	-	-	-	-
City of Titusville Osprey WWTF	$8,000,000	22,988	$349	TBD	TBD
City of Palm Bay WRF	$1,400,000	17,790	$79	TBD	TBD
Septic System Removal	-	-	-	-	-
Banana River Lagoon Septic System Connections	$12,260,000	13,736	$898	N/A	N/A
North IRL Septic System Connections	$12,820,000	14,029	$914	N/A	N/A
Central IRL Septic System Connections	$16,684,000	28,744	$746	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	$9,824,000	12,244	$802	N/A	N/A
Stormwater Projects	-	-	-	-	-
Banana River Lagoon Stormwater Projects	$4,625,000	48,391	$96	6,896	$671
North IRL Stormwater Projects	$4,850,000	52,936	$92	7,632	$635
Central IRL Stormwater Projects	$1,325,000	17,113	$78	2,497	$531
Muck Removal	-	-	-	-	-
Mosquito Lagoon Muck Removal	$16,100,000	35,000	$460	5,250	$3,067
Banana River Lagoon Muck Removal	$71,750,000	165,300	$434	24,800	$2,893
North IRL Muck Removal	$89,250,000	231,500	$386	34,700	$2,572
Central IRL Muck Removal	$21,000,000	59,500	$353	8,900	$2,400
Oyster Reef Living Shorelines	$10,000,000	21,120	$473	7,181	$1,393
Projects Monitoring	$10,000,000	-	-	-	-
Total	***$302,881,000***	***761,929***	***$398 (average)***	***98,670***	***$3,070 (average)***

Table 46: Timeline for Funding Needs

Project Name	Total Project Cost	Cost by Year									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Fertilizer Management/Public Education	$625,000	Year 1 of Program	Year 2 of Program	Year 3 of Program	Year 4 of Program	Year 5 of Program					
		$125,000	$125,000	$125,000	$125,000	$125,000	-	-	-	-	-
WWTF Upgrades	-	-	-	-	-	-	-	-	-	-	-
City of Titusville Osprey WWTF	$8,000,000	Design & Permitting	Bid & Mobilize	Complete Construction	-	-	-	-	-	-	-
		$500,000	$500,000	$7,000,000	-	-	-	-	-	-	-
City of Palm Bay WRF	$1,400,000	Construction	-	-	-	-	-	-	-	-	-
		$1,400,000	-	-	-	-	-	-	-	-	-
Septic System Removal	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$12,260,000	Design & Permitting	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	$1,160,000	$2,780,000	$280,000	$1,960,000	$2,900,000	$960,000	-	-
North IRL	$12,820,000	Design & Permitting	Cocoa K & Melbourne	Cocoa J, Rockledge, Titusville	S Beaches A	South Central C	South Central A	South Central D	Sykes Creek C	-	-
		$500,000	$920,000	$2,540,000	$840,000	$2,640,000	$2,300,000	$1,880,000	$1,200,000	-	-
Central IRL	$16,684,000	Design & Permitting	Palm Bay 1/2 Sewer	Palm Bay 1/2 Sewer	Palm Bay B	West Melbourne	Palm Bay A	-	-	-	-
		$500,000	$3,882,000	$3,882,000	$4,700,000	$2,240,000	$1,480,000	-	-	-	-
Septic System 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	$9,824,000	44 Upgrades	50 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades	65 Upgrades
		$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	$4,625,000	2 Projects	3 Projects	6 Projects	6 Projects	6 Projects	6 Projects	6 Projects	6 Projects	-	-
		$400,000	$475,000	$750,000	$600,000	$600,000	$600,000	$600,000	$600,000	-	-
North IRL	$4,850,000	3 Projects	4 Projects	5 Projects	5 Projects	5 Projects	5 Projects	5 Projects	5 Projects	-	-
		$525,000	$675,000	$750,000	$625,000	$625,000	$625,000	$525,000	$500,000	-	-
Central IRL	$1,325,000	1 Project	1 Project	1 Project	1 Project	1 Project	1 Project	-	-	-	-
		$275,000	$225,000	$225,000	$200,000	$200,000	$200,000	-	-	-	-
Muck Removal	-	-	-	-	-	-	-	-	-	-	-
Mosquito Lagoon	$16,100,000	-	-	-	-	-	-	-	-	Near Haulover Canal	-
		-	-	-	-	-	-	-	-	$16,100,000	-
Banana River Lagoon	$71,750,000	Mathers Bridge Area	8% of Canals	Newfound Harbor Area	8% of Canals	Cape Canaveral Area	8% of Canals	Pineda Causeway Area	8% of Canals	Cocoa Beach Area	8% of Canals
		$5,250,000	$5,250,000	$3,500,000	$5,250,000	$26,250,000	$5,250,000	$3,500,000	$5,250,000	$7,000,000	$5,250,000
North IRL	$89,250,000	1/3 Eau Gallie Area	2/3 Eau Gallie Area	-	Titusville Area	-	1/2 Rockledge Area	1/2 Rockledge Area	Cocoa Area	-	-
		$8,750,000	$17,500,000	-	$14,000,000	-	$14,000,000	$14,000,000	$21,000,000	-	-
Central IRL	$21,000,000	-	-	Mullet Creek Area	-	-	-	Goat Creek Area	-	Melbourne Causeway	Trout Creek Area
		-	-	$7,000,000	-	-	-	$3,500,000	-	$7,000,000	$3,500,000
Oyster Restoration/Living Shorelines	-	-	-	-	-	-	-	-	-	-	-
Banana River Lagoon	$4,230,000	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles	0.846 Miles
		$423,000	$423,000	$423,000	$423,000	$423,000	$423,000	$423,000	$423,000	$423,000	$423,000
North IRL	$4,320,000	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles	0.864 Miles
		$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000	$432,000
Central IRL	$1,450,000	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles	0.290 Miles
		$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
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
Total	***$302,881,000***	***$22,373,000***	***$35,128,000***	***$31,268,000***	***$33,456,000***	***$37,296,000***	***$30,751,000***	***$31,241,000***	***$33,846,000***	***$34,436,000***	***$13,086,000***

Section 7. Funding Needs and Leveraging Opportunities

Brevard County is exploring a variety of possible mechanisms to fund the IRL projects in this plan, and one of these options may be placed on the ballot in November 2016. The options being considered include:

- 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

A Save Our Lagoon referendum of 1 mill or ½ cent sales tax would generate approximately $32 million per year. If one of these options is not selected, an increase in ½ mill would generate $16 million per year. This is approximately half of the revenue needed for projects in each plan year. Therefore, to implement the projects in a timely manner according to the schedule in **Table 46**, the County will seek to use funds generated from the referendum to leverage matching funding from grants and appropriations and/or pay debt service on bonds.

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).
- Community Budget Issue Request – 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).

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Appendix A: Maps of the Septic System Removal Areas

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). Areas 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 A-1** through **Figure A-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 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 included as part of this plan are outlined in green.

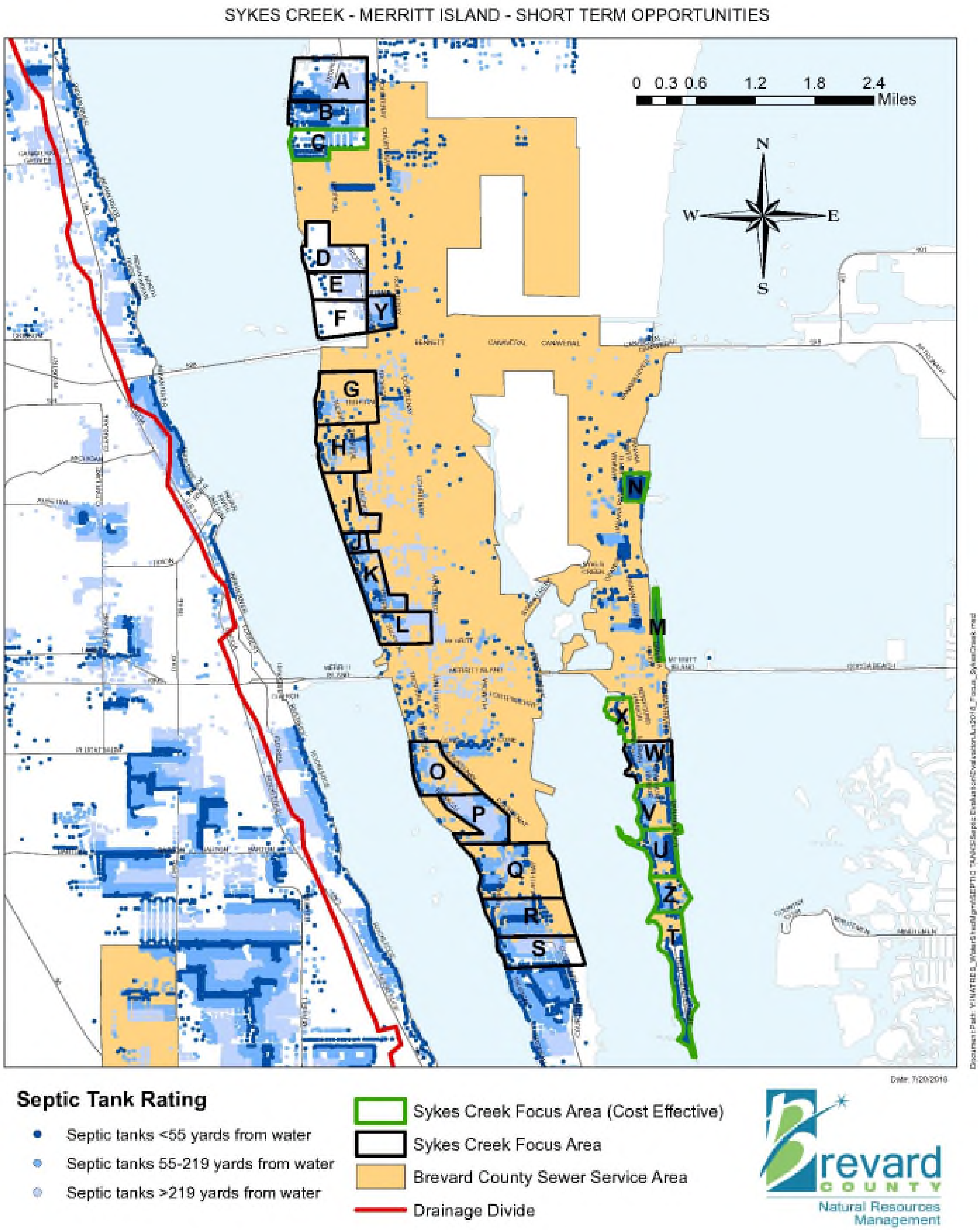
The septic systems within the cities were also evaluated for potential connection to the sewer system. This evaluation was conducted by identifying those areas that had at least 50% of the septic systems within 55 yards of a surface waterbody. The scoring of these systems, as described in **Section 4.1.3**, were also considered. The septic systems with the highest (worst) score are shown in blue in **Figure A-4** through **Figure A-9** The 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 A-1: Map of South Beaches Priority Septic System Areas

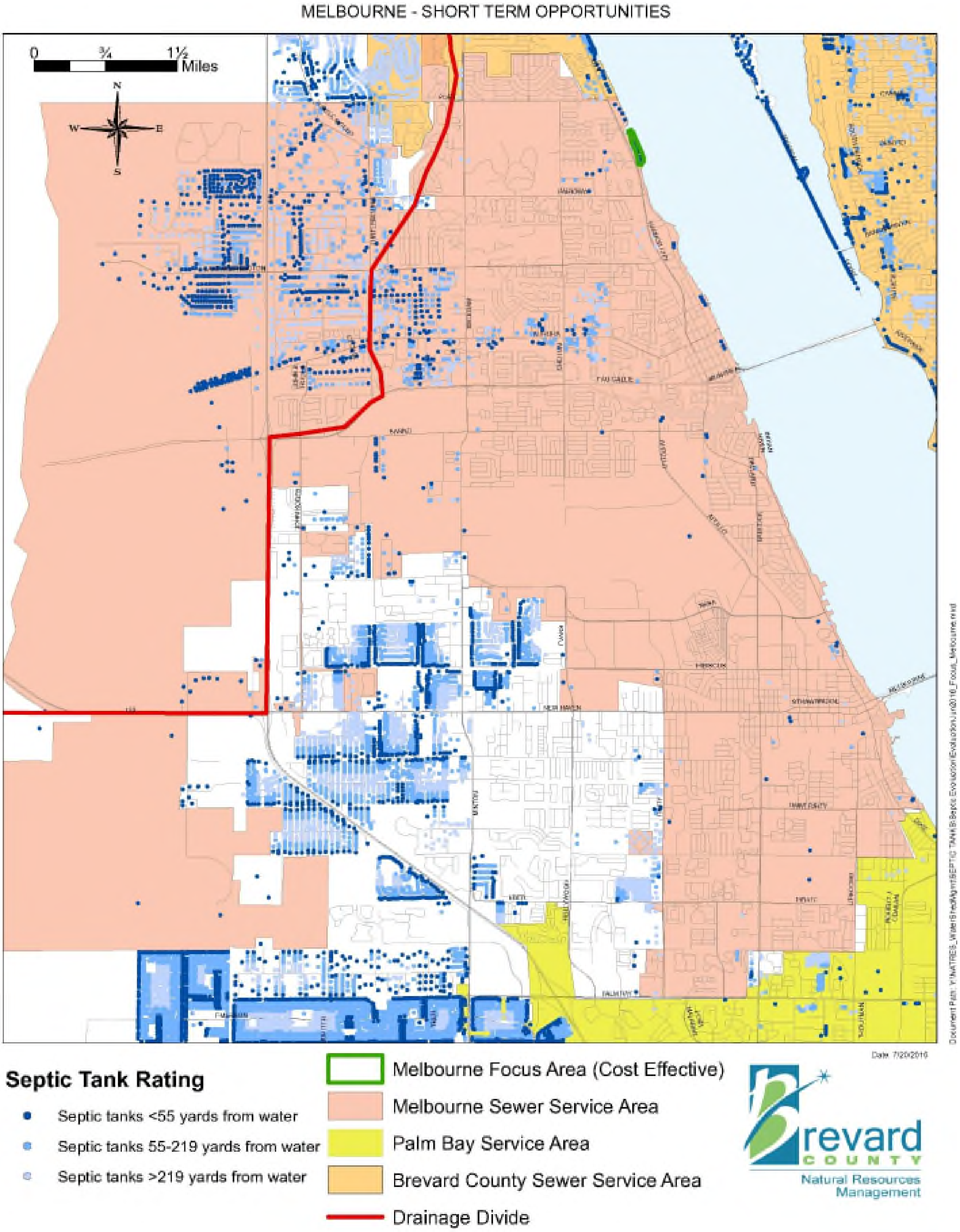
Notes: The focus areas outlined in green are the most cost-effective and are recommended as part of this plan. The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

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



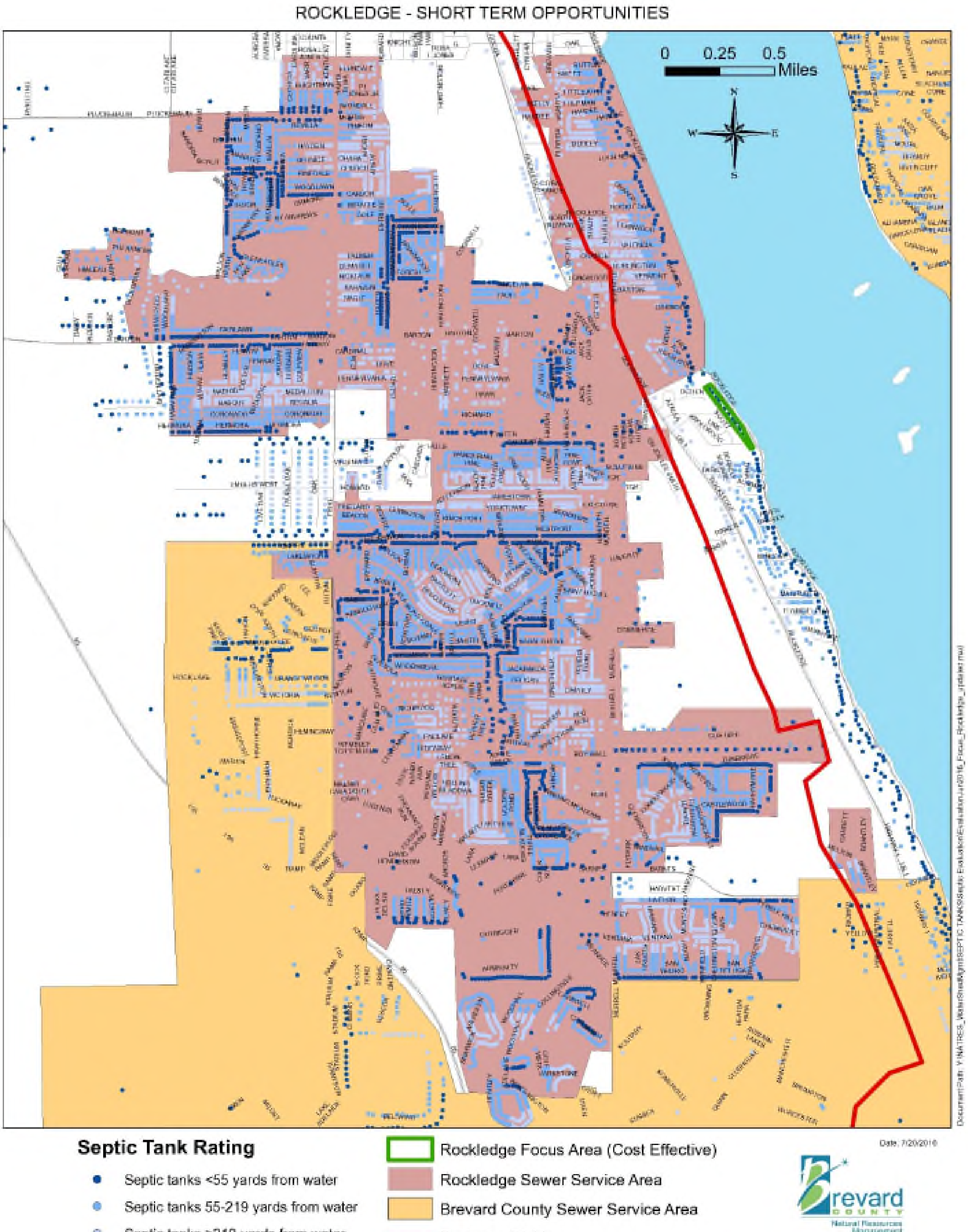
Notes: The focus areas outlined in green are the most cost-effective and are recommended as part of this plan. The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

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



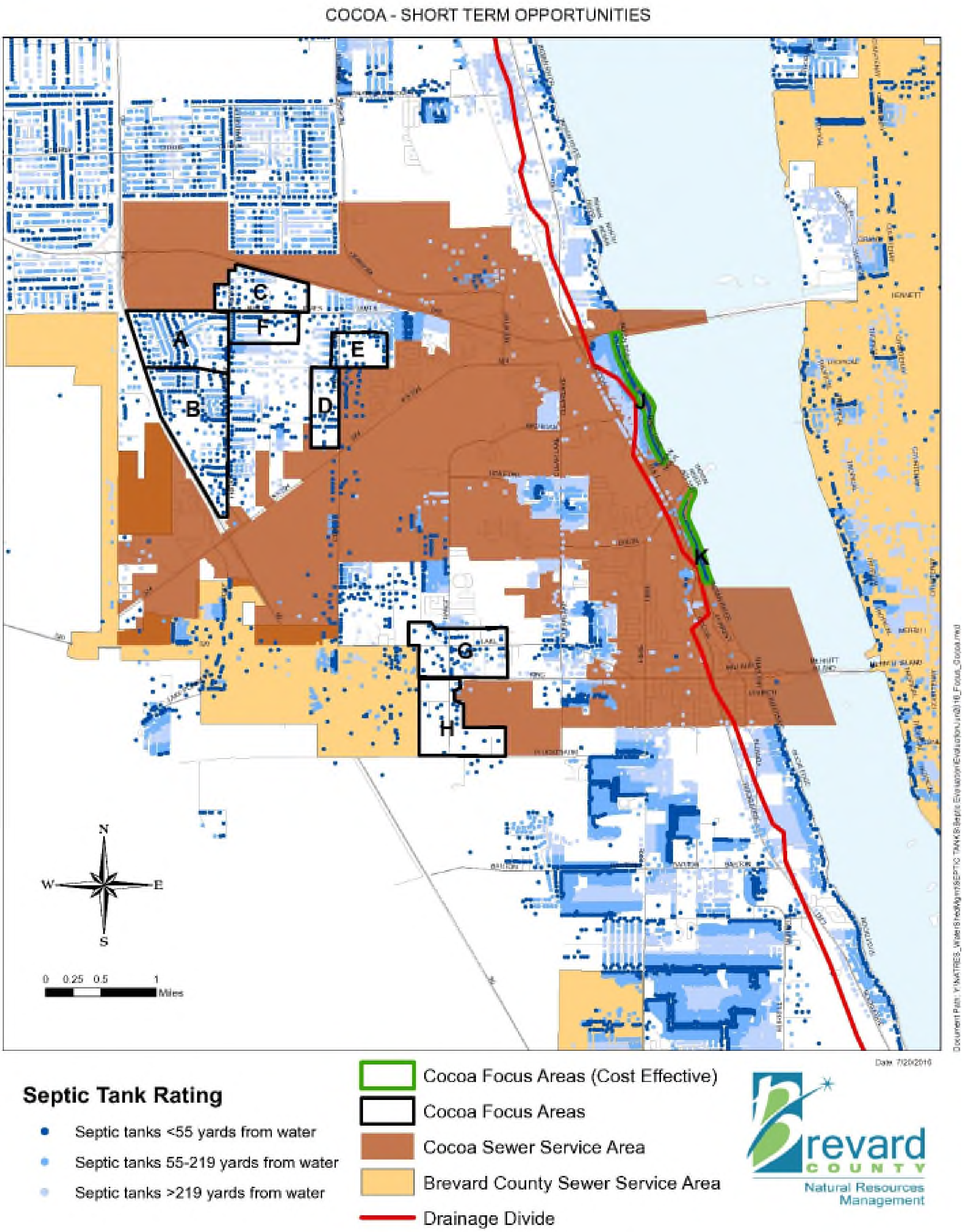
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

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



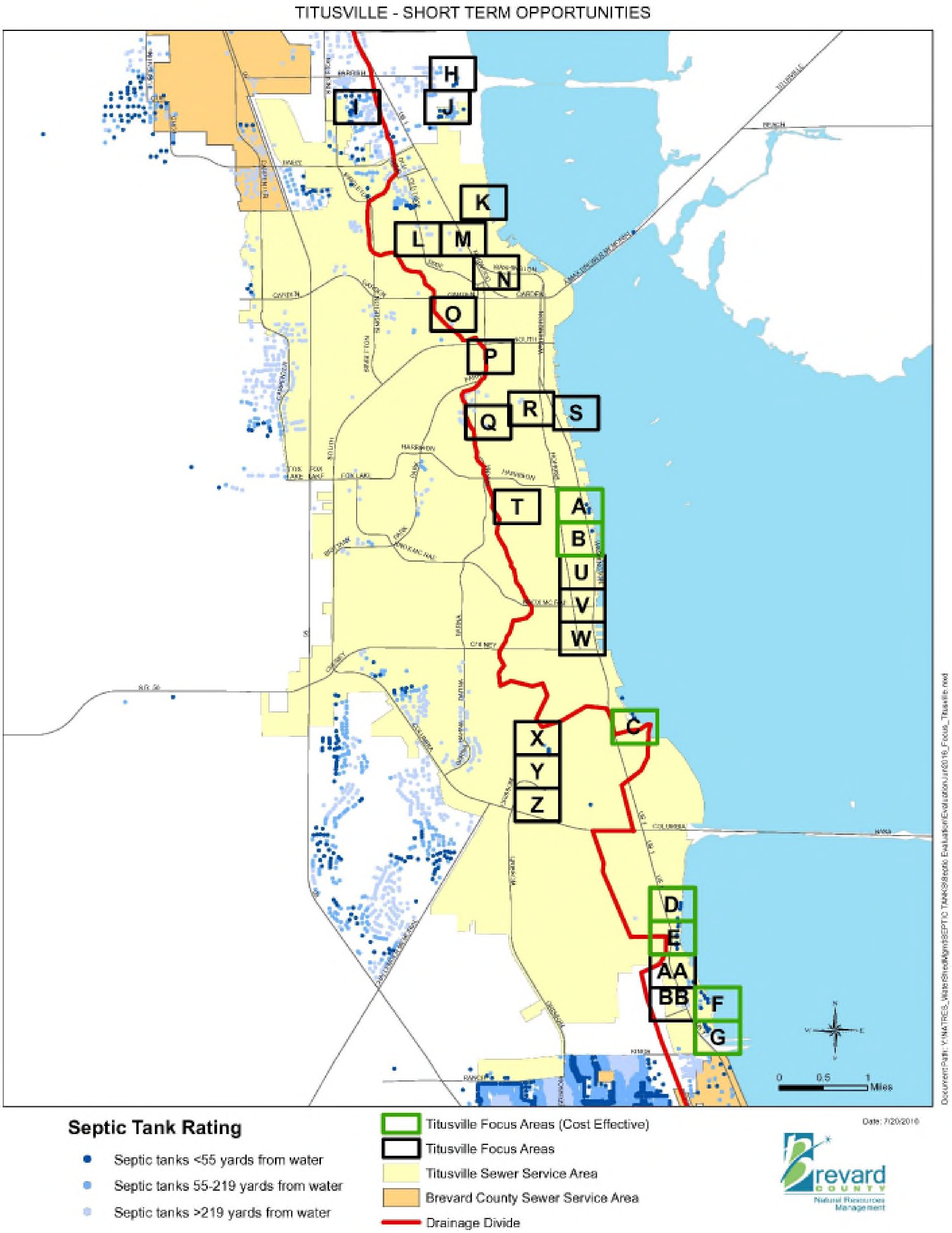
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

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



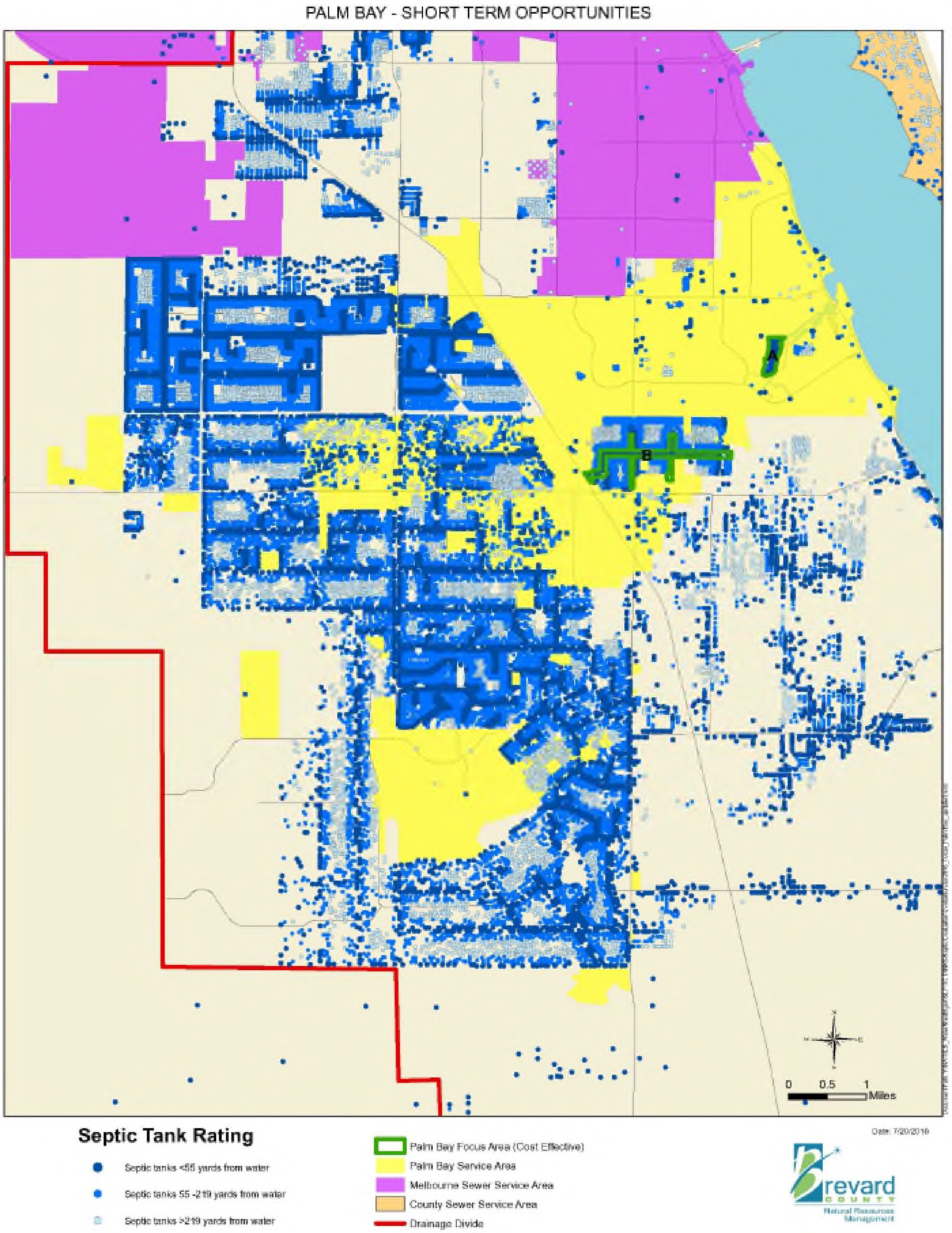
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

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



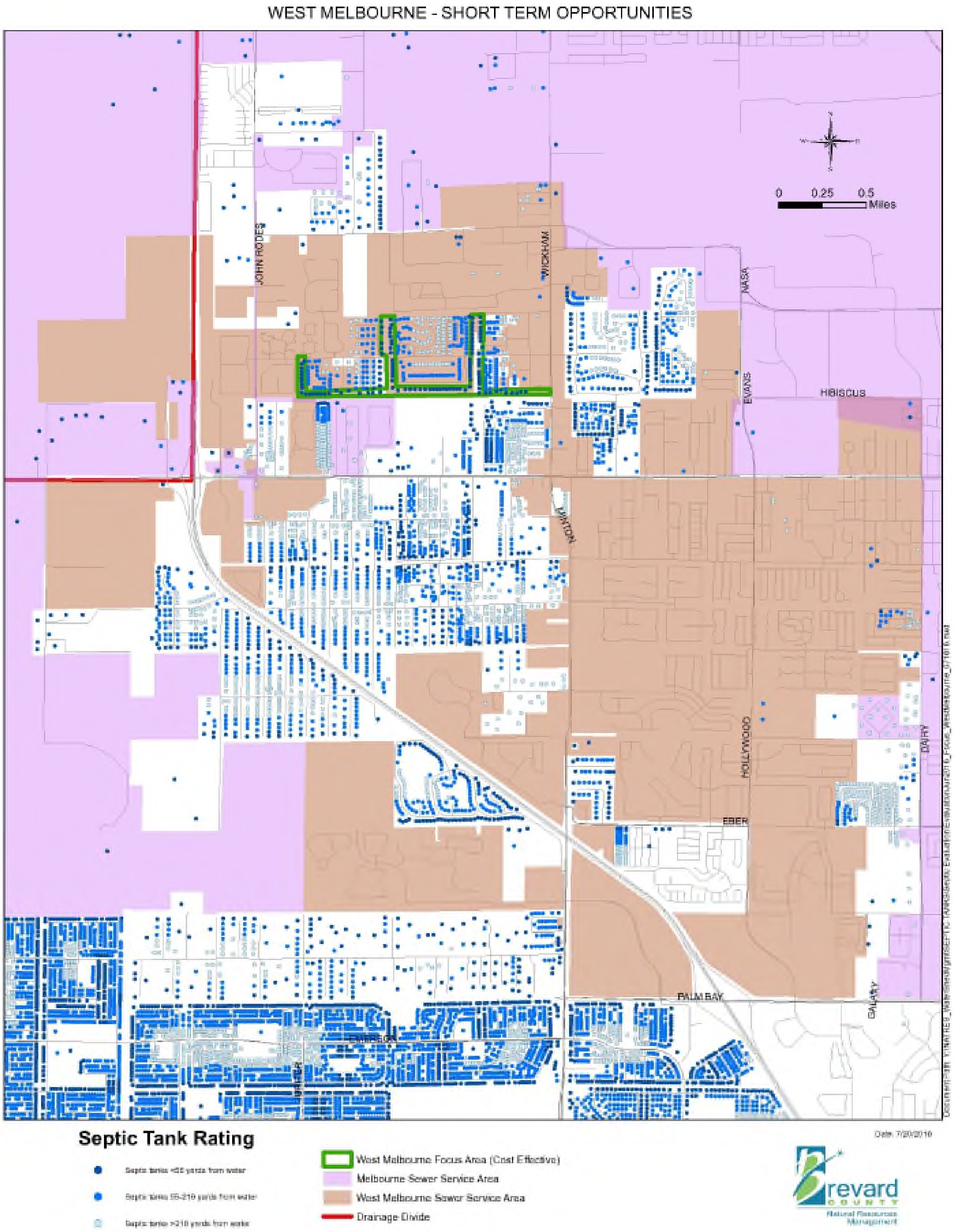
Note: The septic system locations are from the FDOH permit database. This database includes all septic systems permitted since 1980 or that have received repair permits since that time.

Figure A-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 A-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 A-9: Map of City of West Melbourne Priority Septic System Areas

Appendix B: Summary of Stormwater Projects

Table B-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

Table B-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

Table B-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

Table B-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

Table B-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
2159	1,461.5	55.0%	803.8	7,013.8	45.0%	3,156.2
2075	1,422.1	55.0%	782.2	4,993.7	45.0%	2,247.2
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

Table B-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
2159	201.2	65.0%	130.8	801.8	45.0%	360.8
2075	195.8	65.0%	127.3	803.7	45.0%	361.7
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