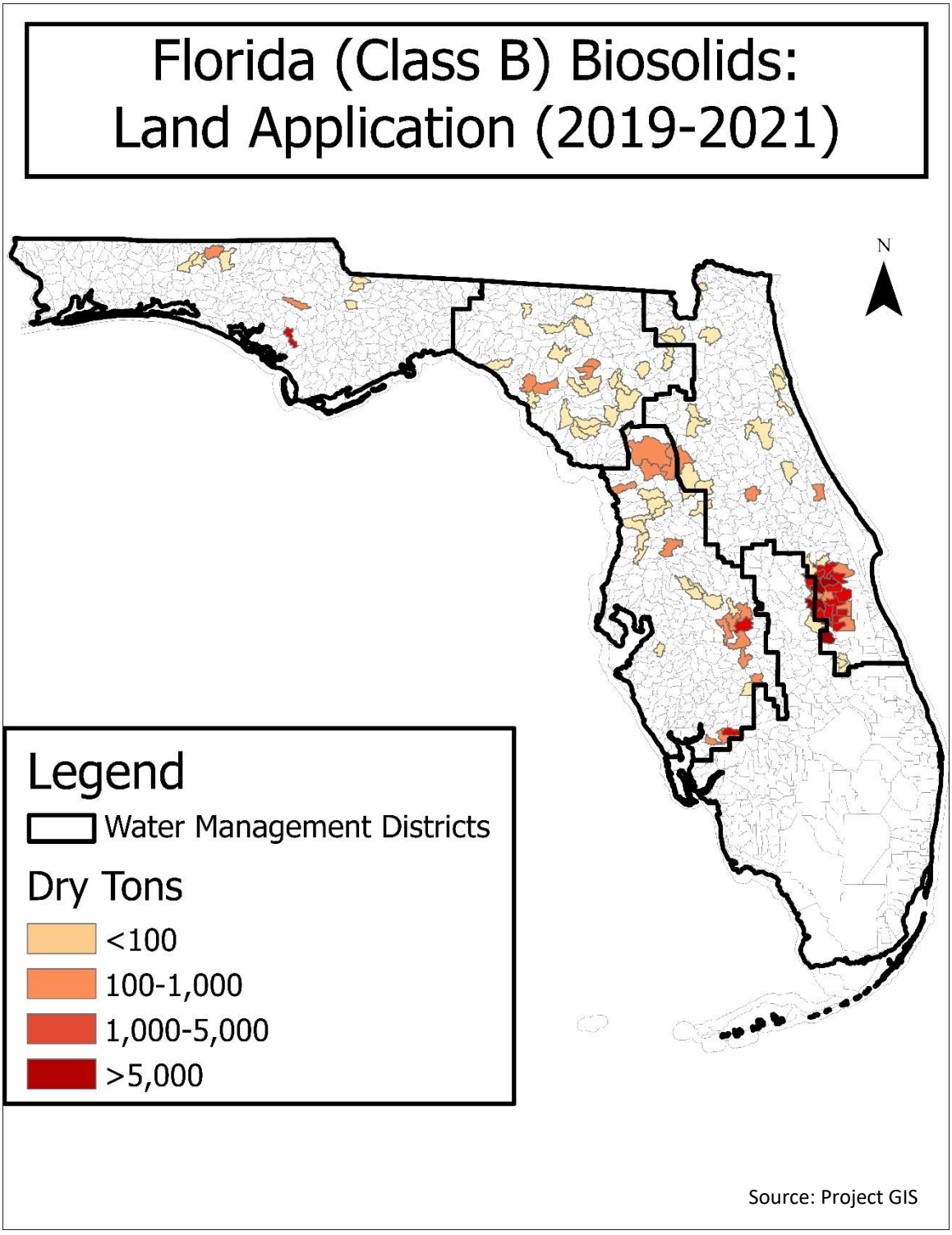
BIOSOLIDS IN FLORIDA

AN ASSESSMENT OF MANAGEMENT AND IMPACTS

May 2025

1000 Friends of Florida



Note: Shaded areas represent watersheds containing permitted biosolids land application sites and the average tons per year applied within each.

EXECUTIVE SUMMARY

The land application of solid residues from sewage treatment plants (known as biosolids) has long been controversial in Florida and increasingly throughout the US. Both regulators and public health and environmental advocates have raised concerns that nutrients, toxic metals or chemicals in these residues might cause pollution of surface or groundwater and thereby affect the health of nearby residents or animals. There are also questions about fairness, as those potentially exposed may not contribute to the public waste in question, or they may also be far away from the source, either in another political boundary or watershed.

It is therefore important to review the State's administrative progress in biosolids management with respect to current data and information on health risks, trends both in disposal and management practices and wastewater utility investment, and what technologies may be available to alleviate the issues of concern.

1000 Friends of Florida received a grant to undertake a study to increase public understanding of the potential health, environmental and socioeconomic implications of the transfer and land application of biosolids within Florida. The scope of work included the following tasks:

- Describe the status of research and data collection concerning the potential health implications of exposure to the most prominent chemicals of emerging concern: Per-and Polyfluoroalkyl Substances (PFAS), as present in biosolids.
- Collect and summarize published research documents and peer-reviewed articles about the production and disposition of biosolids, with an emphasis on Class B biosolids.[1]
- Summarize all applicable Federal and State law regulating biosolids management.
- Conduct spatial analyses of Class B biosolids distribution via a geographic information system (GIS) comprised of relevant State and Federal environmental and permitting data.
- Apply statistics to examine
    - the relationships between Class B application sites and the state's impaired surface waters and its aquifers (groundwater),
    - the environmental characteristics of the watersheds within which biosolids are land-applied, and
    - the transfers of biosolids between Florida counties that generate and export biosolids and the communities that receive them with respect to disparities in median income, ethnicity, and age.
- Conduct a cost-benefit analysis of Class B biosolids management practices currently in use in Florida, including the state of new technology use and development, and their respective direct, indirect and non-market costs and benefits.[2]

[1] Per U.S. Environmental Protection Agency standards, Class B biosolids are those receiving the minimum level of treatment required prior to disposal.

[2] Direct costs were obtained from utilities and the private sector. Estimates of indirect costs (e.g., opportunity costs, such as the loss of the nutrient and soil supplement value of biosolids that are not land-applied) and non-market costs and benefits (e.g., air quality, water quality, public health, and recreation) were informed by published studies of the economics of biosolids management.

- Assess the evolving scope of the issue in Florida as land application of Class B biosolids appears to be diminishing.

A technical report with supporting references and appendices was prepared that summarizes the biosolids management problem faced by Florida, presents all research findings and conclusions, and proposes recommendations. Among other results, the study generated the following key findings:

- PFAS and other contaminants of emerging concern (CECs) in biosolids have become an increasing regulatory concern and potential liability for land applicators of biosolids nationally. Recent reports document the risks of PFAS exposure via biosolids, but specific health impacts unique to biosolids have not been fully assessed. While utilities and the State monitor the presence of PFAS in drinking water, wastewater and biosolids are not monitored for their potential effect on receiving groundwater or surface waters.
- There is a statistically significant correlation between the quantity of land-applied Class B biosolids and the likelihood that receiving surface waters within the same watershed are impaired for nutrients (nitrogen and phosphorus).
- There is a statistically significant correlation between the land application of Class B biosolids and the levels of nitrogen in groundwater within the watersheds of permitted biosolids land application sites.
- The practical effects of statutory provisions have contributed to the practice of transporting Class B biosolids from urban to rural areas and across water management district boundaries.
- The transportation of biosolids generates societal costs [3] not addressed by wastewater management utilities.
- When calculated societal costs are included, the land application of Class B biosolids is the least cost-effective approach among the six in-use practices considered, which included landfilling, conversion to Class AA, composting, and vapor recompression and distillation technologies.
- None of the in-use biosolids treatment technologies reviewed removes all heavy metals (i.e., regulated toxics) or PFAS. Other potential treatment strategies such as thermal processing and supercritical water oxidation remain insufficiently tested at scale. Anaerobic digestion has moved beyond the pilot phase but has received negative attention because of residual PFAS concentrations.
- There remain significant data gaps among in-use practices relating to the control of PFAS, greenhouse gas emissions, and operating costs that hinder the advancement of cost-feasible biosolids management options that can reduce the risks of current biosolids management.

The study concludes that the current regulatory and management frameworks for all classes of biosolids result in the transfer of a concentrated byproduct from urban residents and visitors served by centralized (municipal) wastewater treatment facilities that imposes environmental impacts and potential health risks for the receiving, rural areas of the state as well as indirect societal costs.

[3] For this study, monetized societal costs include impacts to regional air quality from truck transport of biosolids, and impacts to surface and ground water quality from nutrients in land-applied biosolids, including property value, and loss of recreational use, in sum, impacts to the public-at-large. To avoid any inferences about economic impacts to any specific demographic group the term “social costs” has not been used.

As of 2024, Florida produces more than 384,000 dry tons of biosolids (all classes) and land applies at least 84,000 dry tons of Class B biosolids across about 85 permitted sites. Thirty-three counties transfer their Class B biosolids to other counties for land application, with eight counties responsible for 76% of the Class B biosolids for which there are records of transfer. With Florida's population and number of visitors continuing to increase, the volume of biosolids will only grow.

To improve environmental outcomes, potential public health issues and address any inequity across political boundaries, watersheds and water management districts, 1000 Friends of Florida offers the following recommendations aimed at improving current practices, incentivizing the introduction of advanced treatment technologies and continual improvement aimed towards eliminating the application on our land of levels of toxic chemicals, metals and excessive nutrients known to cause health or environmental risks.

- Florida must adopt a comprehensive approach to biosolids management with principles that
    a. minimize environmental impacts and any potential health issues;
    b. reduce the externalities (indirect societal costs) associated with transport of biosolids, especially for receiving counties; and
    c. assign the total costs of management (including externalities) to the generators of biosolids.
- Florida must advance the collection and dissemination of accurate data regarding biosolids on several fronts:
    - A monitoring and data collection program should be specifically aimed at groundwater and surface water adjacent to existing (and future) areas of land application, with the costs to be shared as appropriate between biosolids generators and receivers.
    - An assessment should be made of EPA-designated priority PFAS compounds in wastewater and the environment in Florida.
    - A State agency should be tasked and appropriately funded to carry out these measurements, update them regularly, and routinely report to the public.
    - In addition to environmental monitoring, the State's role as a clearinghouse for information about evolving technologies should be bolstered, especially to support local governments' and utilities' efforts to better manage biosolids and to improve compliance reporting.
- To better understand the impacts of biosolids within watersheds and upon state-designated waterbodies, the State should track the distribution of both Class AA and more highly composted biosolids separately from synthetic, chemical fertilizers. Class AA production data, nominally collected by FDACS, should be incorporated into DEP's watershed protection responsibilities, such as preparing and updating BMAPs and reducing land application of biosolids (both Class B and Class AA) that may contribute to surface water impairment.
- To (a) reduce inequity in the distribution of societal impacts, (b) reduce future general revenue expenditures for remedial action necessitated by the land application of biosolids, and (c) fund incentives programs to transition to better biosolids management (including new, more effective technologies), the State should establish a biosolids generator fee similar to those in place for hazardous materials, tires, and lead-acid batteries. The biosolids generator fee is general in its intent to improve biosolids management statewide.

- While utilities that export Class B biosolids incorporate that transportation cost into their customer rates, a surcharge — above that of the biosolids generator fee — should be considered to reflect the difference in levels of treatment being provided (and any associated environmental costs). Utilities that produce Class AA biosolids or more highly composted products have already internalized some of their societal costs and would not be subject to the surcharge.
- The State should direct sufficient funds levied from fees on generators of biosolids (or amend its current grant program) to foster innovation aimed at development, scaling and early adoption of new technologies to reduce risks from biosolids. The program should prioritize funding for technologies that will reduce the greatest potential harm to the environment, based on the reduction in quantity of harmful contaminants to be land applied, sensitivity of the location and environment, and innovation of the technology with careful reporting on both efficacy and long-term efficiency. The program should expand financial incentives for producing and marketing less environmentally risky biosolids products.
- As may relate to the presence of PFAS and CECs, the State should address the issue of the potential liability of both wastewater utilities and property owners where land application of Class B biosolids has occurred (or may be proposed for future disposal). A comprehensive monitoring program for PFAS, such as that contemplated by Oregon, should be considered.[4]

It is our intent to circulate these recommendations to the public and the Florida Legislature as well as the Executive Branch. We understand that everyone may not agree with these recommendations, but trust this will serve as a good starting point for serious, long-awaited and much-needed improvement in wastewater residuals management.

[4] Loew, 2025. Among other states, Oregon lawmakers propose to study PFAS in agricultural fields where biosolids are applied. The study would analyze PFAS concentrations in biosolids, soil, and crops, with voluntary participation from wastewater facilities and farmers. The legislature also looks to regulate PFAS in firefighting foam and the sale of products with intentionally added PFAS.

ACKNOWLEDGEMENTS

This project would not have been possible without the support of a grant from the Sea Grape Foundation.

Key contributors and reviewers over the course of the project include the members of its Technical Review Panel:

Doug Bournique	Indian River Citrus League | Executive Vice President St. Johns River Water Management District Governing Board
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Comments provided by the Technical Review Panel members do not constitute endorsement of the report's conclusions and recommendations.

Additional thanks are due to Elio Fernandez (Ph.D., candidate, Florida State University Department of Urban and Regional Planning), Dr. Chris DeBodisco (High Point University Department of Economics and the firm of Environmental Economics Consulting), and Craig Diamond, research manager.

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ACRONYMS AND ABBREVIATIONS

bgd – billions of gallons per day

bgy – billions of gallons per year

BMAP – Basin Management Action Plan

CA – confined aquifer

CAPEX – capital expenditures

CECs – contaminants of emerging concern

CFR – Code of Federal Regulations

DACS – Florida Department of Agriculture and Consumer Services; references may use FDACS

DEP – Florida Department of Environmental Protection; references may use FDEP

EPA – United States Environmental Protection Agency; references may use USEPA

EDR – (Florida Legislature) Office of Economic and Demographic Research

FAC – Florida Administrative Code

FS – Florida Statutes

GIS – geographic information system

GDB – geodatabase

gpd – gallons per day

gppd – gallons per person per day

HUC – Hydrologic Unit Code

KWH – kilowatt-hour

LOWCP – Lake Okeechobee Watershed Construction Project

mgd – millions of gallons per day

mg/l – milligrams per liter (parts per million)

ng/l – nanograms per liter (parts per trillion)

NBDP – National Biosolids Data Project

NHD – National Hydrography Dataset

NMP — Nutrient Management Plan

NH_3 —ammonia

NH_4 —ammonium (NH_4^{+1})

NO_3 —nitrate (NO_3^{-1})

NWFWMD – Northwest Florida Water Management District

OFS – Outstanding Florida Springs

OFS – Outstanding Florida Waters

OPEX – operations expenditures

OSTDS – onsite treatment and disposal system

PAHs – polycyclic aromatic hydrocarbons

ppb – parts per billion

ppm – parts per million

ppt – parts per trillion (*not parts per thousand*)

PFAS – per- and polyfluoroalkyl substances

PFOA – perfluoro-octanoic acid

PFOS – perfluoro-octane sulfonic acid

PO_4 — ortho-phosphate (PO_4^{-3})

POTW – publicly owned treatment works

RPC – (Florida) regional planning council

SFWMD – South Florida Water Management District

SJRWMD – St. Johns River Water Management District

SMN – Status Monitoring Network

SRWMD – Suwannee River Water Management District

SWFWMD – Southwest Florida Water Management District

TMDL – Total Maximum Daily Load

TN – total nitrogen

TP – total phosphorus

µg/l – micrograms per liter (parts per billion)

UA – unconfined aquifer

USDA – United States Department of Agriculture

USGS – United States Geological Survey

WBD – Watershed Boundary Dataset

WBID – Waterbody Identification Assessment Unit

WEP – Water Extractable Phosphorus

WIN — Watershed Information Network

WTE – waste-to-energy

WWTF – wastewater treatment facility

ISSUE BACKGROUND AND CONTEXT OF THE PROBLEM

Biosolids, referred to as "night soil," have a lengthy history.[1,2,3] The mythology of use (and re-use) of human waste extends several millennia to that of imperial China, to Amazonian middens, to 18th century Japan (where the product itself was a component of property rights), and to more recent cultural paradigms regarding the recycling of needed resources.

As defined by the EPA, "biosolids are a product of the wastewater treatment process. During wastewater treatment the liquids are separated from the solids. Those solids are then treated physically and chemically to produce a semisolid, nutrient-rich product known as biosolids. The terms 'biosolids', 'wastewater residuals', 'residuals', and 'sewage sludge' are often used interchangeably."[4,5]

In 1990, when ocean disposal of sewage (i.e., the liquid effluent from wastewater treatment facilities) was banned, the United States Environmental Protection Agency (EPA) began recommending the spreading of sewage sludge on the soils of farms and forests. The agency considered the practice of land application a form of recycling and thus a beneficial use. The EPA fashioned a euphemism, "biosolids," to provide an appearance of safety and thereby improve public acceptance of its disposition in the larger landscape; per Federal regulation, contaminants in this waste stream did not need to be disclosed to the public except for the requirement that the distributed product not contain excessive levels of eight metals (and one non-metal). As a waste product, biosolids are presumed noxious. Per the dictum, "There is no such thing as away. When you throw something away, it must go somewhere."[6]

While the land application of biosolids represents one means to recycle materials otherwise deemed as waste, the practice — especially in Florida — poses multiple concerns, outlined as follows. Each is discussed in further detail within the following Technical Report.

- Biosolids production is inextricably linked to wastewater generation, and wastewater generation is in turn driven by the state's effective population (residents plus tourists). Florida's effective population continues to grow and the challenges of biosolids management increase accordingly.
- Data regarding biosolids production and management rely primarily on utility reporting. However, accuracy, completeness and reporting compliance vary over time and the data compiled by agencies reflect significant uncertainty in published figures. Federal, state and non-governmental organization reports on the magnitude of biosolids production, processing, and

[1] https://daily.jstor.org/a-history-of-human-waste-as-fertilizer/
[2] https://www.washingtonpost.com/lifestyle/home/would-you-use-human-waste-in-your-garden/2017/08/22/43556b90-82b4-11e7-b359-15a3617c767b_story.html
[3] https://ojs.ethnobiology.org/index.php/ebl/article/view/1351
[4] https://www.epa.gov/biosolids/basic-information-about-biosolids
[5] For purposes of this report, "biosolids" includes Class B, Class A, Class AA and composted products containing biosolids. Distinctions by class are provided wherever applicable.
[6] Annie Leonard, "The Story of Stuff." 2007. Adapted from Barry Commoner, "The Closing Circle." 1971. "Everything must go somewhere. There is no 'waste' in nature and there is no 'away' to which things can be thrown."

disposition are not readily reconcilable. Accurate information regarding biosolids is important for its effective management.

- Landfill capacity in many Florida counties is limited.[7] While biosolids are often blended with soil to serve as required daily cover for landfills, exporting biosolids is one means to preserve capacity for other types of municipal waste that are less readily recycled.[8]
- Agricultural lands suitable for receiving biosolids are limited or largely absent in urban counties. The shortage of nearby lands for the spreading of treated septage necessitates some measure of transportation beyond that of nearby municipal solid-waste facilities, i.e., landfills. The transportation of biosolids, whether wet or dry, imposes direct costs for the producers of biosolids and the indirect societal costs related to vehicular exhaust of greenhouse gases and unburnt fuel contributing to reduction in air quality, and diminished property values or recreation use associated with water quality impacts that may be attributable to biosolids in the landscape.
- The land application of Class B biosolids is inequitably distributed across Florida's geography. Related to the above consideration of limited agricultural lands in urban areas, Florida has adopted laws and regulations limiting the land application of biosolids within select counties in southern Florida.[9] While not an outright ban within the Lake Okeechobee watershed, the transportation of biosolids generated by the more highly populated counties in South Florida has become part of a rational economic response to the constraint of nutrient loading to the Lake. In sum, the current legal framework is attempting to protect some surface waters at the expense of others. An analysis of the relative values and restoration needs of receiving waters in South Florida versus those of central and northeastern Florida (especially the St. Johns River) has not been conducted to provide a basis for this statewide policy.
- Florida has been identified as the state with the largest total acreage of polluted lakes and reservoirs (based on state Integrated Water Reports filed with EPA).[10] The vegetative uptake of applied nutrients (and economic export of agricultural products) cannot be 100% efficient. Consequently, the land application of biosolids in Florida necessarily contributes to some of these longstanding surface water quality problems, particularly as relates to nitrogen and phosphorus, key factors in the formation of harmful algal blooms — both freshwater and, eventually, estuarine/coastal.
- Within the 155 watersheds that feature Class B biosolids land application sites, 61 watersheds (39%) contain or intersect with an Outstanding Florida Water (OFW). Of these 61 watersheds, 45 are hydrologically connected to an OFW and subject to a Basin Management Action Plan (BMAP), under which DEP has programmed reductions of nutrients and other water quality parameters to restore the impaired aquatic ecosystems.

[7] https://www.waste360.com/landfill/south-florida-s-landfills-are-reaching-capacity-officials-looking-for-solutions
[8] https://www.epa.gov/sites/default/files/2018-11/documents/biosolids-technology-factsheet.pdf
[9] Local governments have adopted ordinances controlling land application of biosolids as well.
[10] https://environmentalintegrity.org/reports/the-clean-water-act-at-50/

- Further, of the watersheds containing Class B biosolids land application sites, 46 (30%) intersect an Outstanding Florida Spring (OFS) springshed (i.e., the land area contributing to groundwater that flows from a spring). Of these 46 watersheds, 17 are specifically impaired for nutrients and are subject to a BMAP.
- Biosolids present added water quality concerns in the form of "forever chemicals," dominated by per- and polyfluoroalkyl substances (PFAS). PFAS do not break down readily under traditional (secondary) wastewater treatment processes and therefore remain within transported and land-applied biosolids. The compounds, some of which are toxic and bio-accumulate,[11] may then enter ground and surface waters at or downstream from biosolids land application sites. In the past year, these chemicals have been receiving greater scrutiny by the EPA and other states. Recent lawsuits against the EPA such as those filed by Maine Organic Farmers and Gardeners Association (May 2024), and Public Employees for Environmental Responsibility (June 2024) may prompt further Federal regulation of PFAS. Contaminants of Emerging Concern (CECs) and PFAS in particular present a potential liability for biosolids generators and applicators. Reducing concentrations of CECs at the source (i.e., the wastewater treatment facility) reduces concentrations in biosolids and thereby decreases this risk. The prospectives costs to utilities and their customers for such reductions are understood to be significant.

To summarize, the context of biosolids management includes growth in the magnitude of disposal problem, the exclusion of multiple South Florida counties where Class B biosolids can be practically placed, a large number of impaired watersheds elsewhere in the state that need to constrain the quantities of fertilizer (including biosolids products) that may be applied, and increasing liability concerns related to PFAS and the likelihood of further regulation.

STUDY FINDINGS

Pursuant to both Federal and State law, biosolids are partitioned by "class" with respect to the degree of reduction in pathogens and disease-carrying vectors and the concentrations of various metals known to impact health. The DEP's labels in sequence from the least to the greatest risk for human exposure are as follows: Class AA, Class A, and Class B. The majority of biosolids generated in Florida belong to either the Class AA or Class B categories. All classes of biosolids are land applied.

Biosolids production data – and therefore these findings -- rely primarily on local wastewater utility reporting. However, accuracy, completeness and reporting compliance vary over time, and the data collected by agencies reflect significant uncertainty in final figures. Agency reports on the magnitude of biosolids production, processing, and disposition are not often readily reconcilable.

Biosolids Production

Biosolids production is inextricably linked to the state's effective population (of residents plus tourists). Florida's effective population continues to grow, and wastewater (and therefore biosolids) generation can be assumed to increase roughly linearly with population and tourism. [See Technical Report, Appendix A.]

[11] Bio-accumulation refers to increasing concentrations of substances in living organisms.

- This study estimates that as of 2021 there are approximately 365,400 dry tons of biosolids (all classes) processed annually in-state.[12]
- Based on population growth, the 2024 estimated generation of biosolids is 384,580 dry tons.[13]

Historically, approximately one-third of this amount (as Class B) has been land-applied, one-third distributed and marketed as fertilizer, and the remaining one-third landfilled.[14] However, recent data indicate a marked shift away from Class B production and towards Class AA: There are about 41 facilities producing Class AA biosolids in Florida with 192,879 dry tons distributed and marketed within the state and 26,717 dry tons distributed and marketed outside the state (a total of 235,268 dry tons Class AA, about 64% of all biosolids produced). [See Appendices A and B.] This is a significant industry trend over a relatively short period of time, emphasizing the continued demand for fertilizer and soil supplements in the residential and agricultural sectors.

Land Application of Class B Biosolids

Permits and permit renewals for land application through the DEP vary annually, but there remain about 130 permitted Class B biosolids land application sites in Florida covering more than 46,000 acres.[15,16] The number of sites continuing to receive Class B biosolids has, however, declined over the past several years (through 2021) and is believed to now be 85. Almost all Class B biosolids land application sites in Florida grow hay crops or are pastures, improved and unimproved; some sod farms also receive Class B biosolids. In the St. Johns River basin, citrus groves received Class B biosolids in the past but universally no longer do so. Orange groves in southwest Florida do receive Class AA biosolids products, but not Class B.

Biosolids Impacts on Surface Water Quality

While there is limited documentation on the direct effects of land application of Class B biosolids on nearby surface waters in Florida[17], the statistics conducted in this study do identify select correlations between both land application and the quantities applied with the likelihood that a waterbody has been designated as "impaired" (for one or more nutrients).[18] This study focused on nutrients (nitrogen and phosphorus) as measured constituents in biosolids for which impairment of waters is determined. Nutrients can contribute to other impairments such as chlorophyll α, turbidity or dissolved oxygen (all via stimulated algal growth) without violating thresholds for the nutrients themselves. Rather than infer the cause of impairment (which may have multiple sources), the study was restricted to the parameters for which biosolids have documented content.

The permitted land application of Class B biosolids occurs in watersheds designated by the State of Florida for advanced levels of protection. Specifically, within the 155 watersheds that feature Class B

[12] Dry tons are equal to the wet weight of septage multiplied by the percent solids, which can vary based on based on the degree of drying and separation of liquids.
[13] Dry ton is the general term for biosolids mass. It is equal to the wet tonnage multiplied by the percent solids. In turn, wet tons (i.e., septage separated from effluent) are calculated roughly as 8.3 lbs per gallon of septage.
[14] In sum, at least two-thirds of all biosolids produced are land-applied.
[15] DEP, 2018
[16] DEP's 2021 SERC for Rule Chapter 62-640, FAC, reported 80,000 acres with active application of biosolids within a pool of 92,377 acres permitted for land application.
[17] See Canion et. al., 2021 and 2022 for one key nutrient migration study.
[18] Impairment is defined by under Florida's "Impaired Water Rule" that provides a methodology to identify waters to be included in the State's Clean Water Act Section 303(d) list of impaired waters.

land application sites, 61 watersheds (39% of the total) contain or intersect an Outstanding Florida Water (OFW). Approximately 17,500 dry tons of Class B biosolids are annually applied within these watersheds. Of these 61 watersheds, 45 (receiving a total of about 12,000 tons annually) have a direct nexus to an OFW (i.e., they are hydrologically connected) and are currently subject to a Basin Management Action Plan (BMAP), under which DEP has programmed reductions of nutrients and other water quality parameters to achieve levels that restore the impaired aquatic ecosystems.

Further, of the 155 watersheds containing Class B land application sites, 46 (30% of the total) intersect an Outstanding Florida Spring (OFS) springshed (i.e., the land area contributing to groundwater that flows from a spring). These watersheds with a nexus to springs have an average of 2,570 dry tons applied annually. Of these 46 watersheds, 17 are specifically impaired for nutrients (and are subject to a BMAP).

This study was not designed to determine a unique cause-and-effect relationship between the land application of Class B (or Class AA) biosolids and water quality issues but highlights the presence of these nutrient sources within the watersheds of State-designated water bodies that are subject to stricter regulations and which are statutorily programmed for improvement to address standards not being achieved.

In the context of the sizes of watersheds[19] evaluated, the distances between the center of application sites and the geographic center of an impaired water within the same watershed were not large or diverse enough to determine a significant correlation based on distance alone.

TABLE 1. LOGISTIC REGRESSION RESULTS: CLASS B APPLICATION AND IMPAIRMENT OF WATER BODIES

Class B Application Rate	Increase in Odds of Impairment for TN, TP
100 Ton/yr	1.02
1,000 Ton/yr	1.26
5,000 Ton/yr	3.23
10,000 Ton/yr	10.43
20,000 Ton/yr	108.85

Source: Study Statistics, Appendix E

Per the results of logistic regressions, while small, the odds of impairment for nutrients (TN and TP) do increase for every one-unit increase in (a) the quantities land applied and (b) an index that relates both quantity and distance to the nearest waterbody. The increase in the probability of impairment becomes more significant with larger applications (e.g., greater than 5,000 tons per year).

Class AA Considerations: The biosolids processing industry continues to shift from Class B to Class AA production. While DEP actively monitors the sites for Class B disposal, permitting statistical analysis such as conducted in this study, detailed information at the county and watershed levels regarding the

[19] The study relied on the USGS boundaries for Hydrologic Unit Code (HUC) level 12 watersheds, the smallest areas that contain defined stream segments or lakes.

volumes and locations of Class AA products is lacking.[20] As a result, the potential impacts of increasing volumes of Class AA biosolids on water quality have not been thoroughly assessed.[21]

At the simplest level, the application of Class AA products to the landscape adds to existing nutrient loadings if there is no concomitant reduction in fertilizer use. A detailed nutrient budget at the farm level would be required to evaluate the net nutrient impacts of Class AA use, and then scaled to address the effects within watersheds.

Class AA biosolids are commodities: the nutrient content is not "free" and agricultural enterprises ordinarily will optimize application volumes and fertilizer substitutions or replacements contingent upon changes in operational costs and farm yields. In sum, Class AA biosolids products are not purchased and applied indiscriminately, disregarding soil health or water resource protection efforts. While not regulated as Class B is, the marketplace does dictate in part where, when, and how often Class AA products are applied.

Most significantly, assessments of the water quality impacts of biosolids (both Class B and Class AA) need to reflect the rates of mineralization (and therefore the mobility and plant availability of their nutrients), which are typically less than those observed in inorganic (synthetic) fertilizers. Florida-specific studies offer a range of values but conclude that the nutrient loss to the environment (as a percentage of volume applied) from commercial fertilizers may be as high as 38% for phosphorus and 46% for nitrogen. The respective rates of loss from biosolids, especially when highly composted, are significantly smaller.

With regard to nitrogen, Florida and EPA studies indicate that at any point in time the degree of mineralization (i.e., the conversion to a form that becomes labile and can be readily taken up by plants) is affected by both how biosolids were treated and how long since they were land applied. The EPA (1995) had determined that aerobically treated biosolids yielded about 30% first year mineralization, 20% for anaerobically treated and 10% for composted. In addition, these mineralization rates decline by approximately 50% per year until there is a residual of about 3% of the original concentration. Extrapolation of this first order rate of decay results in a cap of about 55% total mineralization for aerobically digested biosolids (Class B), 38% for anaerobically digested biosolids, and about 18% for composted biosolids. Applying these total mineralization rates to initial concentrations suggests that about 3.0% of the TN in Class B biosolids is biologically available, about 2.1% of Class AA, and as little as 0.2% for highly composted biosolids products. As this process occurs over a period of about three years, the majority of mineralized nitrogen may be captured by successive crop cycles and the remainder is effectively unavailable in the short term.

Unlike nitrogen, phosphorus in biosolids is largely in the form of inorganic (and bound) phosphates of iron, aluminum and calcium.[22] As a consequence, the labile and plant available phosphorus (i.e., water extractable phosphorus) in biosolids is less than that associated with commercial fertilizers and manures which are manufactured to provide readily available phosphorus.

[20] As an example, Lee County (2014) indicated that 85% of its Class AA product was distributed within the county; Palm Beach County, however, reported that most of its Class AA product was exported.
[21] While incorporating data on fertilizer use, Basin Management Action Plans do not uniformly partition these supplements into synthetic (i.e., manufactured) fertilizers, uncomposted biosolids, or composted biosolids.
[22] Phosphorus is released from these compounds under acidic conditions; biosolids and soil amendments such as biochar (derived from biosolids) raises soil pH and minimizes such release.

Further, while the basic (dried and pelletized) Class AA product has the same concentrations of total nitrogen and total phosphorus associated with Class B (i.e., approximately 5.0% and 2.3%, respectively), highly composted products — an increasing share of the market — have TN and TP concentrations roughly 20% of Class B: 1% and 0.5%, respectively. Combined with the relatively low rates of mineralization and increased moisture and nutrient retention capability (because of their soil amendment properties) highly composted Class AA products present a smaller threat to receiving waters and offer a reduction in nutrient loading relative to current practices involving synthetic fertilizers and Class B biosolids. To the extent that biosolids are a significant component of nutrient loading within a BMAP, switching to highly composted products should reduce annual loading from that source.[23]

Environmental Justice Considerations of Transferred Class B Biosolids

The changes in Florida law that intensified the export of Class B biosolids from South Florida to the St. Johns River watershed are a transfer of water pollution. At the county level, the more urban South Florida counties exhibit higher incomes within their larger economies and the more rural counties may have a larger percentage of marginalized communities. As a result, the study anticipated marked differences in the racial and economic makeups of counties exporting biosolids versus those counties receiving biosolids and that the transfer of Class B biosolids would represent an environmental justice concern.

However, but for a couple of specific county-to-county relationships, the study did not identify statistically significant differences in the income, age (with vulnerable populations both under age 5 and older than age 60), and ethnicity between counties that produce biosolids and those that receive them. At the county-wide level, in general, the higher-population and more urban producers of biosolids did not exhibit statistically significant higher incomes than receiving counties, nor did they have higher non-white and non-Hispanic percentages of the population. To expand this issue, the mean values for median income were in fact higher among counties exporting biosolids, but the variation in U.S. Census socio-economic data among these counties rendered the difference to be not statistically significant. Further, several of the census block groups containing biosolids land application sites had higher median incomes than the counties exporting biosolids. Their populations, however, were older.

- In sum, the variability of demographic and socio-economic data among Florida counties is large enough to outweigh potential signals of environmental injustice.

The Costs and Benefits of Select Biosolids Management Practices

Six biosolids management practices — all in use in Florida — were considered: conventional landfilling, land application (Class B only), conventional composting, conversion to Class AA, advanced or extended composting, and Sedron Technology's vapor recompression and distillation technology ("Varcor"), with groundbreaking for the Indiantown facility expected in 2025. Each management approach was considered in isolation; the study did not seek to optimize any combination of strategies. Non-market costs[24] and benefits unique to each management approach were identified and incorporated. Estimates of capital and operating costs were based on available information and proprietary information was not available for some of the in-use practices. The analysis is sensitive to the non-market costs and benefits of receiving water quality, including the shadow costs of nutrient pollution.

[23] As noted elsewhere in this report, highly composted biosolids products

[24] Non-market costs include societal costs.

- When both direct and non-market costs and benefits are taken into consideration, only vapor recompression and distillation approaches a benefit-cost ratio of 1.0. *Based on these tabulations, the predominant options for the current management of biosolids are an economic drain on the State*.
- Except for landfilling, the direct costs for land application of Class B biosolids are the least among the practices reviewed. However, the non-market costs (i.e., transferred environmental impacts) of land application are more than ten times greater than the alternatives.

TABLE 2. SUMMARY OF COSTS AND BENEFITS OF BIOSOLIDS MANAGEMENT (PER 1000 DRY TONS)

	---------- 10-Year Economic Horizon ----------			
Management Practice	**Total Costs (millions)**	**Total Benefits (millions)**	**Benefit Cost Ratio**	**Ratio Relative to Land Application**
Landfill Only	$5.35	$2.84	0.53	7.9
Land Application Only	$16.19	$1.00	0.07	1.0
Conventional Composting Only	$12.79	$5.23	0.41	6.1
Conversion to Class AA	$14.00	$5.31	0.38	5.7
Extended Composting	$9.01	$6.13	0.68	10.2
Sedron-Varcor	$7.01	$6.90	0.98	14.7

Source: Appendix H

Adjusted for 3% inflation and a discount rate of 7% over a 10-year operational horizon, estimated total costs are highest for land applications and decrease for higher levels of treatment. Total benefits are least for land application and are greatest for vapor recompression and distillation. The benefits of all in-use practices are less than their respective costs (i.e., a negative net benefit). In these instances, the alternative practices ordinarily are not economically justifiable. However, the ratio of the other in-use practices relative to that of Class B land application is greater than 1.0 and these are therefore economically preferable, with the vapor recompression and distillation technology having the greatest ratio, followed by extended composting to a low available nutrient, high organic content product.

Because of the limited new expenses for additional increments of biosolids handled, landfilling is the cheapest option. The market value of nutrients was included in the landfill only option, as these would otherwise need to be purchased. However, the foregone soil amendment and moisture retention values of biosolids — even Class B — were not accounted for, which would increase total costs and reduce the ratio relative to land application.

Land application and composting approaches are more costly than landfilling due in large part to the direct costs of transport and associated generation of greenhouse gases.[25] While economies of scale in construction and on-site operation may be assumed for a regional approach to vapor recompression

[25] In this study, the release of carbon dioxide and methane was evaluated for all management options. Other evaluations consider CO_2 from composting specifically to be biogenic and not anthropogenic and therefore not included in calculations of greenhouse gas (GHG) emissions. Compost products may include organic materials such as yard waste, food scraps, biosolids, and manures. Diverting these materials from landfills reduces methane emissions and can provide the added benefit of carbon sequestration in soil.

and distillation technology, total costs will be greater because of transportation. The increase in benefits will not be directly proportional to the increase in total costs.

Regulations

Despite a state permitting program for the land application of Class B biosolids, there is no comprehensively planned system of regulations to manage Florida's growing volume of septage and associated biosolids, with both local and state-level decisions about biosolids management being made with incomplete information that has in turn led to select socially and economically inequitable outcomes.

- Permitted disposition of biosolids occurs on an applicant-by-applicant basis. While cities and host counties may coordinate on treatment and disposal, this is not mandated. Further, opportunities for extra-county coordination have been left primarily to the private sector for the collection, treatment, and distribution of Class AA products.

Contaminants of Emerging Concern

Biosolids have been identified as containing contaminants of emerging concern (CECs). This is the case for not only Class B, but Class AA as well. CECs include chemical compounds found in common household and personal care products. The number of CECs is large and few have been adequately studied. However, of those reviewed several have associated risks to human health and the environment, including toxins and endocrine disruptors.

Predominant among CECs in recent regulatory activity are PFAS (Per- and polyfluoroalkyl substances) and associated chemicals such as perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). PFAS have become a concern because they (1) do not break down readily in the environment, (2) can migrate through soils and thereby contaminate drinking water sources, (3) have been shown to bioaccumulate in wildlife, and (4) have been detected in surface waterbodies. PFAS enter the wastewater treatment stream via industrial, commercial, and domestic sources. *Conventional primary, secondary, and even tertiary wastewater treatment processes (i.e., for pathogen and nutrient reduction) do not materially reduce PFAS concentrations*. Consequently, land application of biosolids introduces PFAS directly into the environment.[26]

While biosolids are not allowed to be applied on farms growing certified organic fruits, vegetables, or dairy products, PFAS concentrations in commercial fertilizers (which may be blended with biosolids) are not regulated. To date, only Maine has banned land application of biosolids because of PFAS concerns. However, other states (and local governments) are considering similar action and have instituted a variety of programs to monitor the situation.

- The regulation of PFAS in biosolids, whether at the source facility or at application sites, is a growing phenomenon nationally.

[26] PFAS concentrations in biosolids and related composted products may be less than those found in consumer products. Depending on the sources of irrigation water, biosolids themselves may not be the only source in land application settings.

- The issue is heightened where PFAS is detected in drinking water, which itself is now subject to tighter standards by the EPA.[27]
- Recent lawsuits against the EPA such as those filed by Maine Organic Farmers and Gardeners Association (May 2024), and Public Employees for Environmental Responsibility (June 2024) may prompt further Federal regulation of PFAS.
- CECs and PFAS in particular present a potential liability for biosolids generators and applicators. Reducing concentrations of CECs at the source (i.e., the wastewater treatment facility) in turn reduces concentrations in biosolids and thereby decreases this risk. The costs to utilities and their customers are understood to be significant.

RECOMMENDATIONS

The report concludes that biosolids management, and the land application of Class B biosolids in particular, warrants amendments to DEP rule and practice to better ensure that the beneficial attributes of biosolids are more effectively deployed while the negative aspects of biosolids are reduced. In sum, the State (including its academic resources) should coordinate with local governments and wastewater utilities to (a) reduce and ultimately eliminate the land application of Class B biosolids and (b) meanwhile employ innovative and cost-effective means to render both Class B and the more widely distributed Class AA biosolids less impactful to the environment.

The following more detailed recommendations recognize that as byproducts of wastewater management biosolids are largely a public resource, and that the distribution of public costs (impacts) and benefits is fundamentally a public responsibility.

- Beyond use as a component of daily cover (which itself contributes to greenhouse gas emissions) the landfilling (i.e., burial) of biosolids is an ineffective use of the resource. Recognizing that the practice is relatively cheap, the societal costs of methane generated and risks from contaminated leachate outweigh any cost savings from landfill disposal.
    - *The total societal costs (including greenhouse gas assessments) of landfilling biosolids should be documented and made available to local governments.*
- Within its BMAPs for impaired waters, the DEP should prioritize the non-renewal or phasing out of Class B biosolids land application permits in conjunction with agricultural BMPs that will reduce total loadings of nutrients. While the loss of biosolids presents the possibility that farmers will increase their respective use of chemical fertilizers to offset the reduction in added nutrients, financial incentives for more aggressive use of BMPs may ameliorate any production or yield impacts.
    - *The recommended phasing out of permits would require directing legislation.*
    - *As data permit, as part of the BMAP process DEP should assess what share of agricultural nutrient loading is derived explicitly from land applied biosolids and amend the BMAP to better control for this source.*

[27] On March 26, 2024, the EPA announced a comment window for a new study of PFAS in wastewater: Proposed Information Collection Request; Comment Request; POTW Influent PFAS Study Data Collection. https://www.federalregister.gov/documents/2024/03/26/2024-06408/proposed-information-collection-request-comment-request-potw-influent-pfas-study-data-collection

- Despite the agronomic benefits of the nutrients and humic material received in the form of biosolids, the intercounty transfer of biosolids represents an imposed cost on receiving communities. The cost includes the economic value of any declines in receiving water quality, potential losses in recreation, property value, etc. reasonably linked to land application of biosolids. Intercounty transfers of Class B biosolids also impose public costs, including greenhouse gas emissions and State efforts to plan for and remediate affected waterbodies. The classical economic remedy for this condition is referred to as a Pigovian Tax, i.e., a tax on market transactions that create a negative externality or cost borne by individuals not directly involved in the transaction.[28]
    - *The State should direct a comprehensive study of the total economic costs of biosolids transfers to estimate the magnitude of externality and the funds required to ameliorate the circumstances.*
- Taxes do have a negative connotation. The monies described as Pigovian could be collected as an assessment or fee, based on a wastewater account, rather than as a tax based on the quantity of usage. However, classes of assessments could be considered, such as residential vs. commercial, or small vs. large wastewater generators. The State collects a variety of uncontroversial fees for environmental purposes (e.g., tire and battery disposal); biosolids management may be handled similarly. The funds could be administered through a trust fund and thereby avoid impacting general revenues.
    - *The recommended establishment of a dedicated fund to address biosolids would require directing legislation.*
    - *The fund could support restoration of waterbodies impacted by biosolids, the pilot grant program, compensation for (receiving) local governments for any revenues lost that are attributable to the land application of biosolids, and potential liabilities associated with PFAS in biosolids.*
    - *The statewide wastewater residuals fee described above should be set to ensure that the near-term research and data needs are fully funded without impact on general revenues or agency budgets.*
    - *The residuals fee would create an economic incentive to process biosolids in more efficient, less environmentally and societally impactful ways.*
    - *The residuals fee could include a surcharge specific to utilities that export Class B biosolids; utilities that do not export Class B biosolids have already internalized the costs of higher levels of biosolids treatment.*
- In 2023, the State approved a pilot program for innovative technologies that render biosolids less environmentally impactful. The program should be evaluated to determine if additional funding is needed to scale-up promising approaches or to tailor proven approaches to different parts of the state and different biosolids markets.[29]

[28] For example, the societal costs of waterways impacted by the land application of biosolids would be added to the utility costs for wastewater management. In this manner, those directly responsible for the impacts bear the costs for waterway restoration, or, should there be an impact to property values or recreational use, the tax paid would compensate for the loss in users' value. The increase in costs to the generators is then an incentive to shift to technologies that produce fewer impacts.

[29] As of 2018, eight of the nine Regional Planning Councils adopted resolutions supporting the use of pilot program.

- *The recommended review of the pilot program would require directing legislation.*
- *Deployment of successful technologies could be accelerated via the use of the trust fund described above.*

- The outcomes of recently filed Clean Water Act litigation against the EPA for failing to regulate PFAS in biosolids are pending as of this study. Florida has a large population and CECs in the environment can be correlated with population and non-point pollution (rather than by point source industrial discharge alone). CECs (with an emphasis on PFAS) can be expected to become a larger consideration in biosolids management as studies document both the breadth of human exposure and the risk. Florida should employ the precautionary principle to foster technologies that minimize residual PFAS in biosolids, regardless of whether landfilled, land applied, or composted for distribution in fertilizers and soil supplements.
- The DEP should be charged more directly to serve as a statewide clearinghouse for biosolids data and management, rather than only collecting reported information (and issuing permits).
  - *The recommended expansion of DEP function would require directing legislation.*
  - *DEP should report annually on the degree to which Class B biosolids are being managed within watersheds subject to BMAPs, including OFWs and OFS.*
- Based on this study, additional research about biosolids management is warranted in six subject areas to support better policy:
  - more accurate collection, reporting compliancy, and reliable tabulation of biosolids data;
  - the costs and benefits of the several categories of management at both local and regional scales (i.e., county-level and multi-county);
  - other scalable technologies that may produce recoverable and reusable products while nullifying the risks posed by heavy metals and CECs (including PFAS) in wastewater residuals;
  - biosolids management and disposition fee structures that shift environmental and related societal costs onto the producers of biosolids from receiving areas while reducing the fiscal impact on state general revenues and water management district ad valorem directed at water quality measures;
  - assessing more completely the export of nutrients from the range and characteristics of sites receiving biosolids; and
  - optimizing the nutrient content and application of Class AA biosolids for the Florida landscape for all major uses (i.e., residential, improved pasture; horticultural), reflecting existing (and reasonably projected) water conditions within BMAPs, including consideration of limitations on use by area and season.[30]

Each of the above research targets for biosolids should be supported and adequately funded through a comprehensive legislative effort to address knowledge gaps in biosolids management.

[30] For short to medium-term agricultural crops, composted biosolids may not serve as a direct replacement for fertilizer: the nutrients in the composted product are readily plant available. Consequently, composted biosolids should be considered more as soil amendment than a fertilizer offset. Composted biosolids can, however, increase the nutrient holding capabilities of the soil, buffer the pH, and increase microbial activity, which in turn can increase nutrient availability from the soil. Following application, synthetic fertilizer inputs can be reduced, retained in the root zone, and utilized more efficiently.

TECHNICAL REPORT

"*Civilization is the distance man has placed between himself and his excreta*."
--- Brian Aldiss[1]

Introduction to the Report

What this Report Is

1000 Friends of Florida (1000 Friends) received a grant to better protect the State's waters by examining the role of the land application of biosolids. 1000 Friends (and its funder) understand that many of Florida's surface waters are nutrient-impaired and that the large-scale land application of biosolids can only worsen the problem. Further, despite a permitting program, there is no comprehensive or sustainable plan to manage Florida's growing volume of sewage, with local and state-level decisions about biosolids management being made with incomplete information that has in turn led to socially and economically inequitable outcomes.

In response, 1000 Friends proposed to undertake a research, outreach, and educational program to better inform decision-makers and the public about the impacts of land application of biosolids. The outreach and educational components would be based in part on a technical report that would fairly present the issues and include supporting data and transparent analyses of environmentally and economically sound approaches to the problem. 1000 Friends has proposed the use of webinars, social media, public appearances and meetings with officials as effective means of communicating report findings.

- This report is intended to fulfill the primary objective of serving as a technical basis for the education and advocacy initiatives contemplated by 1000 Friends and its funder regarding biosolids management in Florida.

What this Report is Not

The scope of study was not intended to develop or present definitive and scientific proof of the environmental impacts and the potential societal and public health consequences of the land application of Class B biosolids. Specifically, the study included no research elements directed at the active monitoring of Class B biosolids application sites or longitudinal studies of water quality in watersheds or groundwater in the vicinity of biosolids application sites (i.e., formal sampling of receiving waters – surface and ground – and associated approved laboratory analyses and appropriate statistics). In the context of land application of biosolids in general, the study does not include operational assessments to evaluate agronomic efficiency or compliance with best practices. Such research is limited in Florida (but would be invaluable) and would be best undertaken by those agencies equipped and staffed in watershed sciences.

The study instead relies primarily on published data. While key relationships between land application sites and specific watersheds and waterbodies in Florida are explored, the report does not generate original data documenting specific impacts or predictions of environmental outcomes (e.g., blue-green algae outbreaks).

[1] "The Dark Light Years" (1964), originally published by Faber & Faber, ISBN: 9780451424976

In addition, while the broad issue of per- and polyfluoroalkyl substances (PFAS) and other contaminants of emerging concern (CECs), such as pharmaceuticals within biosolids, was raised in the initial proposal, the study was not intended to quantify specific hazards (i.e., cancer or other health risks) these substances may present. To a degree, the study's initial research has been superseded by real-time events such as the U.S. Environmental Protection Agency's (EPA) new standards for PFAS in drinking water, initiatives by several states to prohibit land application of biosolids, and legal action under the Clean Water Act against the EPA. These circumstances are discussed in the report in the context of prospective regulation and the economics of options for biosolids disposal.

- This report does not identify specific environmental risks or claims unless supported by published data and existing peer-reviewed research.

The following report and appendices are the bases for all findings and recommendations in this study. The report outlines all methodologies developed and applied and provides a "state of knowledge" summarizing supporting facts and the results of analyses undertaken.

Project Methodology

This study is founded on applied (not original) research. Key responsibilities included collecting the most recently available public and published data, summarizing information, and conducting statistical analyses on quantitative data.

Literature Review and Data Collection

Data collection involved searching on-line public agency information, researching peer-reviewed and other articles and reports (grey literature), and contacting agencies for non-published data. While not limited to the past several years, the literature search concentrated on materials written or generated since 2017 to provide a current basis for analysis. The project bibliography records all material reviewed and used in the report. An annotated bibliography (by category of research) for many of the bibliographic entries is included in the Appendix.

The literature review also included the assembly of relevant Federal and State law governing the management and disposition of biosolids.

Data Assembly

All quantitative data have been assembled and stored in Excel workbooks to permit aggregation, tabular summarization (i.e., pivot tables), and generation of charts. Critically, data were assembled into field and record formats, where applicable, for import into (1) a GIS (Geographic Information System) capable of supporting spatial analysis and map generation and (2) a statistical package for running statistics such as analysis of variance (ANOVA), (Student's) T-tests, and a variety of regressions, including Logit.[2]

GIS Database and Data Management

To address the research responsibilities of the biosolids project, key spatial data obtained for this report to support analysis of biosolids generation and land application include the following sources and parameters; supplemental details about these sources are provided below.

[2] Excel supports many of the statistical routines run for this study.

- Geopolitical Boundaries (Florida Geospatial Data Library)
    - *County*
    - *Water Management District*
- Hydrography (USGS – National Hydrography Dataset)
    - *NHDFlowline (Stream Network)*
    - *Trace Network*
- Watersheds (USGS – National Watershed Boundary Dataset)
    - *HUC8*
    - *HUC12*
- Topography & Soil (NRCS – Soil Survey Geographic Database)
    - *Slope*
    - *Water Table Depth*
    - *Flooding Frequency (Dominant & Maximum)*
    - *Drainage (Dominant & Wettest)*
- Land Cover (Florida Fish & Wildlife Conservation Commission – Cooperative Land Cover 3.6)
    - *Improved Pasture (IP)*
    - *Cropland Pasture*
    - *High-Intensity Urban (HIU)*
    - *Low-Intensity Urban (LIU)*
    - *Other Agriculture (OA)*
    - *Rural (RU)*
- Demographic Data (US Census)
    - *County*
    - *Block Group*
    - *Population*
    - *Race*
    - *Percent Non-White*
    - *Income*
    - *Age*
    - *Under 5*
    - *Over 60*
- Biosolids (DEP – Domestic Wastewater Program – Information Portal)
    - *Land Application Sites*
    - *Class B Quantities*
    - *Class AA Quantities*
- Septic Tank Installations (DEP – Onsite Sewage Program)
    - *County New OSTDS Installations*
- Landfill Facilities (DEP – Division of Waste Management)
    - *Publicly Owned*
    - *Class II Accepting*
    - *Composting*
    - *WTE*

- Waters Not Attaining Standards (DEP – Division of Environmental Assessment and Restoration)
  - *TN*
  - *TP*
  - *TN & TP*
- State Designated Waters (DEP – Division of Environmental Assessment and Restoration)
  - *Outstanding Florida Waters (OFW)*
  - *Outstanding Florida Springs (OFS)*[3]
- Groundwater Wells (DEP – Division of Environmental Assessment and Restoration, Status Monitoring Network, SMN)
  - *Well Locations*
- Groundwater Quality (DEP – Division of Environmental Assessment and Restoration, Watershed Information Network, WIN)
  - *TN*
  - *TP*

Geopolitical Boundaries: Spatial data for Florida block groups and for counties were obtained from the United States Census Bureau's 2020 TIGER/Line Shapefiles File Transfer Protocol (FTP) Archive by State.[4] The state geopolitical data (county boundaries and water management district boundaries were joined with the census information to provide a base map (and datafile) for organizing all other spatial themes.

Counties were selected as the primary spatial unit to assess several biosolids trends and relationships as counties are a fundamental geopolitical unit and are the primary agency for wastewater facilities generating biosolids.[5] As larger county-based wastewater facilities often serve the majority of (or the larger) municipalities therein, city-level data were generally not explored. County-level findings can also be used to inform counties on local regulations, policies, monitoring, and community engagement practices related to biosolids management.

Spatial data for the Florida Water Management District (WMD) boundaries were obtained from Florida's State Geographic Information Office.[6] The spatial data for the Florida WMD boundaries were last updated on October 31, 2021. In this study, WMD boundaries were used as a spatial unit to assess biosolids trends as WMDs are responsible for the administration of water resources at the regional level.

Demographics: Block groups were selected as the spatial demographic unit to assess more localized impacts of biosolids land application as biosolids management practices may not affect all communities within a county equally. Block groups generally contain between 600 and 3,000 people and can be used to represent a neighborhood or small community within a census tract.[7]

County and Block Group Demographic data were obtained from the 2020 Decennial Census and the 2020 American Community Survey (ACS) 5-Year Estimates through the US Census data dissemination site (https://data.census.gov/). The state geopolitical data (county boundaries, block group boundaries,

[3] The OFS dataset includes the associated springsheds.
[4] https://www2.census.gov/geo/tiger/TIGER2020PL/STATE/
[5] https://floridadep.gov/water/domestic-wastewater/content/wastewater-facility-information
[6] https://geodata.floridagio.gov/
[7] https://www.census.gov/programs-surveys/geography/about/glossary.html#par_textimage_4

and water management district boundaries) were joined with the census information to provide a base map (and datafile) for organizing all other spatial themes.

Watersheds: Within this study, watersheds are the fundamental unit for environmental analyses and most other data were linked to watershed boundaries using GIS routines.

Spatial data for Florida Hydrologic Unit Code watersheds (HUC8 and HUC12) were obtained from the U.S. Geological Survey's (USGS) Watershed Boundary Dataset (WBD) that comes with the National Hydrography Dataset (NHD) last updated March 6, 2023.[8] These two datasets were used to identify trends within natural boundaries as all flowing surface water converges to a single point, such as a river mouth, or flows into another body of water, such as a lake, within watersheds.[9] While the HUC12 files provide the highest level of detail, at that scale water transfers among watersheds can depend on local stages (e.g., tied to local rainfall, or irrigation and pumping) as well as topography and basic hydrography. For these reasons, HUC8 watersheds were used to assess regional patterns.

Each watershed and any associated application site were then linked to each Census block group and county using the Spatial Join (Analysis) tool.[10] The Intersect Match Option was chosen in a One-to-Many Join Operation since multiple watersheds are distributed within and across different block groups and counties.

Hydrography (Stream Networks): Spatial data for stream networks were obtained as part of the NHD. The NHDFlowline (stream network) provides a network topology that enables advanced analytic functionality such as the ability to set flow direction.

The Create Trace Network (Trace Network) tool was used to migrate the Stream geometric network into ArcGIS Pro and to create a trace network. The Enable Network Topology (Trace Network) tool was then used to create the network topology and establish connectivity in the trace network. The Display Flow Direction (Trace Network) command was used to graphically present the flow of water and thereby select all HUC12 watersheds and impaired waterbodies (TN, TP, TN or TP) immediately downstream from HUC12 watersheds with an application site. This analysis was used to assess watersheds that may be influenced by Class B applications in neighboring watersheds during wet seasons and to identify watersheds that could limit future applications of Class B biosolids for water quality restoration purposes.

Topography, Soil, & Land Cover: Spatial data for Florida's topography and soils classes were obtained from the Natural Resources Conservation Service's (NRCS) Soil Survey Geographic Database (SSURGO).[11] The data are collected at scales ranging from 1:12,000 to 1:63,360 and are based on map units that describe soils and other components that have unique properties, interpretations, and productivity. The spatial data include information related to available water capacity, soil reaction, electrical conductivity, and frequency of flooding; yields for cropland, woodland, rangeland, and pastureland; and limitations

[8] https://www.usgs.gov/national-hydrography/access-national-hydrography-products
[9] https://www.usgs.gov/centers/california-water-science-center/science/science-topics/watersheds#:~:text=A%20watershed%20is%20an%20area,point%20along%20a%20stream%20channel; https://pubs.usgs.gov/tm/11/a3/pdf/tm11-a3_5ed.pdf; https://pubs.usgs.gov/wsp/wsp2294/html/pdf.html
[10] https://pro.arcgis.com/en/pro-app/3.1/tool-reference/analysis/spatial-join.htm
[11] https://www.nrcs.usda.gov/resources/data-and-reports/soil-survey-geographic-database-ssurgo

affecting recreational development, building site development, and other engineering uses. Slope, Depth to Water Table (WTD), Flooding Frequency (Dominant & Maximum), and Drainage (Dominant & Wettest) were among the variables chosen to evaluate biophysical factors contributing to surface runoff and potential leaching of pollutants to waterbodies and within watersheds with Class B application sites.

Spatial data for Florida's Land Cover were obtained from the Florida Fish and Wildlife Conservation Commission's (FWC) Cooperative Land Cover (CLC), Version 3.6 published in 2022.[12] The CLC spatial database uses the Florida Land Cover Classification System (FLCCS) to classify land cover types and incorporates classifications used by the Florida Natural Areas Inventory (FNAI), the WMDs, and the FWC. The development of this classification system has also undergone review by experts in image processing and classification who have been involved in the classification of Florida habitats. The land cover categories chosen to evaluate any relationship between biosolids applications and receiving water quality include Improved Pasture (IP), Cropland Pasture (CP), High-Intensity Urban (HIU), Low-Intensity Urban (LIU), Other Agriculture (OA), and Rural (RU).

Each soil map unit and land cover type were then linked to each watershed using the Spatial Join (Analysis) tool. The Intersect Match Option was chosen in a One-to-Many Join Operation since multiple map units and land cover types are distributed within and across different watersheds. The average metric for all map units and the average area (Square Miles) representing each variable across each watershed was then calculated using the Dissolve (Data Management) tool.

Each watershed (above) and any associated application site, topographical, and land cover characteristics were then linked to each block group, county, and WMD using the Spatial Join (Analysis) tool. The Intersect Match Option was chosen in a One-to-Many Join Operation since multiple watersheds are distributed within and across different block groups, counties, and WMDs. The Intersect Match Option is used if join features intersect the target feature and a One-to-Many Join Operation joins features that have the same spatial relationship with a single target feature while retaining multiple copies of the target feature in the output feature class.

Impaired Waters: Spatial data for "Waters Not Attaining Standard" were obtained from the DEP's Water Quality Restoration Program within the Division of Environmental Assessment and Restoration.[13] The data include Waterbody Identification Assessment Units (WBIDs) identified as impaired by not attaining water quality standards (per EPA assessment categories 4a, 4b, 4d, 4e, & 5) through the 2020-2022 Biennial Assessment, even if a Total Maximum Daily Load (TMDL) has been written. WBIDs were selected if they were found to be impaired by either Total Nitrogen (TN), Total Phosphorus (TP), or the derived category "TN or TP", which provides an additional DEP designation of impairment (and record search). The "TN or TP" category was created by using the Select By Attribute geoprocessing tool to query WBIDS impaired for either "TN" OR "TP." This makes it possible to identify waterbodies impaired by TN, TP, or TN and TP considering some waterbodies are impaired by multiple pollutants. The Dissolve (Data Management) tool was used again along with the FIRST statistic to remove duplicate WBIDs in the "TN or TP" category.

[12] https://myfwc.com/research/gis/wildlife/cooperative-land-cover/
[13] https://floridadep.gov/dear/water-quality-restoration/content/impaired-waters-tmdls-and-basin-management-action-plans

The parameters TN and TP are commonly used indicators for assessing the water quality impacts of biosolids and are readily available and consistently measured across the state of Florida.[14] Excessive application of the nutrients can cause eutrophication and diminish water quality. Many regions have regulations and guidelines that specify limits on the allowable levels of TN and TP. By providing this analysis, wastewater treatment facilities and land managers can ensure compliance and better inform water quality standards.

Impaired waterbodies were in turn linked to each watershed and the associated land application site(s), block group, and county by using the Spatial Join (Analysis) tool. The Intersect Match Option was chosen in a One-to-Many Join Operation since multiple impaired waterbodies are distributed within and across different watersheds, block groups, and counties.

State-designated waters (OFW and OFS) were incorporated into the geodatabase to assess the spatial relationships (distance, adjacency, hydrological connection) between land application sites, their respective watersheds, and the designated features.

Groundwater: Groundwater data were obtained from DEP's Watershed Information Network (WIN). The data represent groundwater monitoring sites included in DEP's Status Monitoring Network (SMN) for groundwater. The SMN measures Florida's freshwater conditions with a known statistical confidence. Within the network, water samples are collected at random and unbiased locations. Each resource (aquifer) is sampled during the same month(s) or "Index Period" each year, which allows for direct comparisons over time. Nearly 700 samples are collected each year. SMN data comprise an important part of Florida's Integrated 303(d) and 305(b) reports. DEP submits these reports to the EPA as required by the Clean Water Act.

The data used for this study cover the years 2019 to 2021 and includes data for Total Phosphorus (as TP, mg/l), Nitrate+Nitrite, and Total Nitrogen (as TN, mg/l) for both unconfined and confined aquifers. There are 641 groundwater monitoring sites featuring these data. Some sites only include measurements for one year while other sites have measurements for multiple years. The "Index Period" ranges between October to December for unconfined aquifers and February to March for confined aquifers.

These groundwater monitoring sites were spatially joined to the HUC12 watershed layer. Since there are multiple groundwater monitoring sites in several watersheds, Arc's dissolve tool was used to aggregate the mean values for TN and TP across all groundwater monitoring sites in each watershed for each year where measurements were provided. This approach provides an average groundwater value for TN and TP for each watershed.

Biosolids Facilities: Spatial data for Class B land application locations were obtained from DEP's Domestic Wastewater Biosolids Program within the Division of Water Resource Management. The data include all permitted receiving sites in Florida since 2018. In addition to permitted volumes (tons), the record attributes (fields) maintained by DEP include facility ID, facility name, water management district, county, application zone number, and digitizer name. The Biosolids Program also reports Class AA data

[14] https://www.researchgate.net/figure/TN-and-TP-of-water-samples-from-different-locations_tbl3_234105428 https://www.mdpi.com/2073-4441/14/10/1643; https://floridadep.gov/sites/default/files/62-640.210_2_e%20Biosolids%20Application%20Site%20Log%2006_21_21.pdf https://static.sjrwmd.com/sjrwmd/technical-reports/technical-publications/SJ2021-03.pdf

by county or company; these data were aggregated at the county level and joined to the county shapefile.

To eliminate any double-counting of biosolids application site data, Class B receiving zones were aggregated by the respective application site using the Dissolve (Data Management) tool.[15] This tool aggregates features based on specified attributes, and the attributes of the features that are aggregated can be summarized or described using a variety of statistics. In this case, the receiving zones were aggregated based on the DEP-assigned facility ID. All attributes of the features aggregated were retained using the FIRST statistic. When the FIRST statistic is used, the specified field value of the first record in the input is used. The GIS shapefile for this theme includes 1,301 specific land application zones.

The annual quantities of biosolids applied to each application site by various wastewater treatment facilities across different counties from 2019 to 2021 were recorded. This information was obtained from the annual reports available on DEP's public records Information Portal for each respective site.[16] The Facility ID for each site was used to search for application site reports, and a database was created to import the information into ArcGIS Pro. Using the Add Join (Data Management) tool the database was linked to each application site based on the common field values of each facility ID. Yearly totals were calculated within the GIS by summing biosolid quantities each year between 2019 to 2021.

Each Class B application site was then linked to each watershed using the Spatial Join (Analysis) tool. The Intersect Match Option was chosen in a One-to-Many Join Operation since multiple application sites were found within and across different watersheds. The Intersect Match Option is used if join features intersect the target feature and a One-to-Many Join Operation joins features that have the same spatial relationship with a single target feature while retaining multiple copies of the target feature in the output feature class.

Landfills continue to receive biosolids. Landfill locations (Class I, active) were obtained from DEP's Division of Waste Management, Permitting and Compliance Assistance Program, Solid Waste Section. The landfill GIS layer was used for within-county evaluations of demographics and socio-economics, for example whether the income levels within a block group containing a landfill differs from that of the county at-large.

- In sum, a comprehensive GIS database was developed to include the state's sub-jurisdictions (counties and water management districts); its 2020 demographics at the block group and county levels; its watersheds, topography, soils, and land cover; its hydrology (stream network and receiving waters); its surface water quality; the locations of biosolids receiving sites; biosolids production data (Class B and AA); and the locations of landfills.

Project Statistics

Statistics were generated at three levels for most of the analysis supporting this report: the block group, the county, and the watershed (either HUC8 or HUC12). As a natural feature, the watersheds may cross census block group and county boundaries. QA/QC during development of the database required manipulation of select records to eliminate double-counting of parameter values, a common outcome of merging layers or themes via overlay and intersect routines within a GIS. Different information is

[15] Actions are labeled by ESRI ARC/GIS routines.
[16] https://prodenv.dep.state.fl.us/DepNexus/public/searchPortal

available at each of the three geospatial scales; determinations of statistical significance were only made within each scale.

Using the Class B biosolids application data from 2019-2021, the statistical assessments undertaken reflect a snapshot in time. A longer-term trend analysis, including the period of record for all permitted Class B application sites, use of less accurate but more frequent American Community Survey (ACS) data, and timing for inclusion on Section 305b reports (every two years) was beyond the scope of this study. Consequently, important considerations such as the cumulative impacts of phosphorus from land applied biosolids were not statistically addressed.

Basic statistics — i.e., counts, minima, maxima, means and medians for quantitative data fields — are readily available within ArcGIS and within Excel where data records were exported for additional processing or for development of graphics. However, ordinary least squares regressions were the primary vehicle for testing for most of relationships between and among variables of interest. STATA Version 14.2 was the statistical software package employed.[17]

The appropriate level of significance for regressions was determined by the costs of making a Type I error (i.e., a "false positive", rejecting the null hypothesis when it is actually true) versus a Type II error (i.e., a "false negative," where the null hypothesis is rejected where it should not have been). In this study we report results with a 90% Confidence Interval (or greater) for two-tailed tests.[18] Two-tailed tests were employed the models (regressions) are used to estimate both positive and negative relationships (i.e., both sign and magnitude).

Because this study uses multiple data sets with differing ranges and scales, heteroskedasticity was a common issue in running various tests for relationships. Heteroskedasticity occurs when the variation surrounding observations of an explanatory factor or variable (such as median income) is not the same across all observations. For example, in a county with a high mean income, the difference between the lowest income census block group and the highest income census block group can be much larger than that of a county with a consistently low level of income across all of its census blocks groups. The condition of heteroskedasticity violates the assumption of normally-distributed data that underlies tools such as Ordinary Least Squares (OLS) regressions and can yield misleading *t*-scores. In sum, heteroskedasticity may lead one to draw incorrect conclusions from model results.

This study corrected the problem of heteroskedasticity in three ways (where applicable):

- First, (where appropriate) explanatory factors were transformed into logarithmically scaled values. This not only reduces the scale of the variables, but also allows for a non-linear fit to the data, thereby improving the explanatory power of the regression model.
- Second, (where applicable) counties exporting biosolids were divided into artificial 'sending' regions equal to the average number of application sites per county across the dataset. County level data values are spread out across these regions equally, so it does not change the underlying values, but it does reduce the scale of biosolids in a single observation.

[17] A typical command line in STATA for regressions in the study is "reg y x, robust for OLS regression estimated with robust errors"

[18] While 95% confidence intervals are the norm in the physical sciences, social sciences often report using smaller confidence intervals, especially where sample sizes are small.

- Finally, the study estimated the model using corrections for heteroskedasticity, i.e., 'robust' error terms. This process directly corrects the calculation of t-scores, allowing the study to increase confidence in its conclusions.

In addition to heteroskedasticity, the regression model may suffer from omitted variable or functional form bias. We tested for this using a Ramsey Reset test and rejected the null hypothesis that there are no systematic biases in the error terms. We corrected for this by changing our variables into log space and testing other explanatory variables for inclusion in the model – such as the number of septic tanks in a block groupcounty – as a proxy for areas that may not be suitable for biosolid applications. Variables that do not add to the model's explanatory power, or do not have strong theoretical support, are dropped in the final model.

Several regressions benefitted from the use of a "Logit" (logistics) model. Logistic regression estimates the probability of an event occurring, in this case the likelihood of a watershed having an impaired waterbody or not based on the independent variable of there being a Class B land application site in the watershed or how many tons of biosolids have been applied. This type of statistical model can be for predictive purposes.

Economics of Biosolids Management Practices

The perspective taken for this study was that of Total Societal Costs, which include both the direct internal public and private costs of biosolids management and the indirect external costs imposed on others by biosolids management activity. Benefit-cost analysis was conducted for six biosolids management practices in use in Florida: conventional landfilling, land application (Class B only), conversion to Class AA, (conventional) composting, advanced composting, and Sedron Technology's vapor recompression and distillation technology (i.e., "Varcor"), under development.

The analysis of each management practice was based on an increment of 1000 dry tons of biosolids to be processed. Other reviews have estimated state-wide costs and benefits based on biosolids production and select local costs[19] but not all cost and benefit factors can be generalized. The increment approach was used as one means to look at cost-effectiveness on a 'per unit' basis that may be applicable to smaller utilities / wastewater service providers as well as larger ones. Each management approach was considered independently; the study did not seek to optimize any combination of strategies.

Cost data for each practice were taken from recently published literature, agency reports and interviews with Florida operators.[20] To the extent practicable, non-market costs and benefits were included in each analysis, relying on published literature. Costs then included direct, indirect, and non-market factors; benefits included direct and non-market factors. The non-market components evaluated depended on the biosolids management approach; each has unique non-market factors. Avoided costs (i.e., for nutrient management in runoff and receiving waters) were generally tabulated in lieu of willingness-to-pay (WTP) values: these are typically more conservative and represent a least-cost approach to the factor. Further, WTP is often calculated as a means to express public or users' preference for a difference in condition (e.g., "what is it worth to you to change the condition of a waterbody from poor to good?"). Avoided costs represent known expenditures to address nutrient pollution by proven technologies.

[19] DEP, 2022; Roderick, 2020

[20] Cost data were not provided for the proposed regional Sedron facility in Indiantown, Fl.

The fundamental approach to benefit-cost analysis included determining the appropriate units of measurement for each factor, determining the price per unit, scaling the quantity of units (or price) per 1000 tons of dry biosolids, and calculating the one-time (i.e., for capital expenditures) or expected annual costs. The projected net present values over a ten-year economic horizon were calculated using an annual fixed inflation rate of 3% and discount rates of 4%, 7% and 10%.[21] All categories of costs were summed as "total costs"; all categories of benefits were summed as "total benefits" and the net benefits (total benefits less total costs) and a benefit-cost ratio were calculated for each practice.

Appendix H reports the analysis for each management practice and includes a reference table documenting the sources used, the publication date of the data, the adjustment required to bring all data to 2023 using the ratio of the current value Consumer Price Index and Construction Cost Index to that at the time of the source data was reported, any further unit adjustments required (such as converting metric to imperial or scaling where appropriate), and the final estimated value of each factor. These values were then incorporated into the benefit-cost analysis tables as part of the calculations of either one-time or annual costs and benefits. Total costs and benefits over the 10-year horizon were then calculated from the annual values, discounted as described above. As constructed, the benefit-cost analysis spreadsheets can be readily updated to incorporate updated information such as revised construction estimates or new peer-reviewed valuations for the impact of greenhouse gases or the value of water quality.

Regulatory Framework for Biosolids Management

The regulatory framework for biosolids is introduced here to ensure a basic understanding of the context of the analysis undertaken and the conclusions drawn. The existing rules have shaped the procedures for the State and local governments for decades; instituting changes to such laws is ordinarily a slow process and presents a key constraint on society's ability to keep up with an evolving and expanding resource management challenge.

Biosolids are managed primarily within a framework of Federal and State regulations. Both levels of regulation are applicable, and one does not supersede the other. Key State of Florida regulations are included in Appendix I.

In general terms at the Federal level, Section 405(d) of the Clean Water Act (1972) requires the EPA to

(1) establish numeric limits and management practices that protect public health and the environment from the reasonably anticipated adverse effects of chemical and microbial pollutants during the use or disposal of sewage sludge and
(2) to review sewage sludge (biosolids) regulations every two years to identify any additional pollutants that may occur in biosolids, and then set regulations for those pollutants if sufficient scientific evidence shows they may harm human health or the environment.

[21] Appendix H includes all benefit-cost results. However, summary data in these finding include results for a discount rate of 7% only.

At the State level, the Florida Legislature established the general framework for biosolids management in Section 403.0855, Florida Statutes (F.S.).[22] Additional details and sections of the relevant statutes are outlined below.

Federal Law

The Clean Water Act requires EPA to establish requirements and management practices for the use and disposal of biosolids. In response, the EPA issued its regulations in 40 CFR (Code of Federal Regulations) Part 503[23]. Part 503 of the Code of Federal Regulations (Standards for the Use or Disposal of Sewage Sludge), regulates sewage sludge that is applied to land, fired in a sewage sludge incinerator, or used at a municipal waste disposal site as part of daily cover. Part 503 includes pollutant limits (primarily heavy metals), requirements for pathogen and vector attraction reduction,[24] management practices, monitoring, recordkeeping, and reporting, among other requirements. The regulations apply to all persons or treatment works that prepare sewage sludge, apply sewage sludge to the land, burn sewage sludge in an incinerator, and to the owners and operators of surface disposal sites.[25]

A touchstone of Part 503 is the classification of biosolids into classes. Although not explicitly defined in the Part 503 rule, EPA uses the term "Exceptional Quality (EQ)" to characterize biosolids that meet low-pollutant and Class A pathogen reduction limits (a virtual absence of pathogens) and that have a reduced level of degradable compounds that attract potential disease vectors. Once the requirements are met, Class A EQ biosolids are considered a product that is virtually unregulated for use, whether used in bulk, or sold or given away in bags or other containers.

Similarly undefined in Part 503, EPA uses the term "Pollutant Concentration (PC)" to refer to biosolids that meet the same low-pollutant concentration limits as EQ biosolids, but only meet Class B pathogen reduction and/or are subjected to site management practices rather than treatment options to reduce vector attraction properties. Unlike EQ, PC biosolids may only be applied in bulk and are subject to general requirements and management practices; however, the tracking of pollutant loadings to the land is not required. Florida does not employ this category.

State of Florida Law

Subsection 373.4595(2)(b), F.S., provides the legislative definition of biosolids:

> *"Biosolids" means the solid, semisolid, or liquid residue generated during the treatment of domestic wastewater in a domestic wastewater treatment facility, formerly known as "domestic wastewater residuals" or "residuals," and includes products and treated material from biosolids treatment facilities and septage management facilities regulated by the department. The term does not include the treated effluent or reclaimed water from a domestic wastewater treatment facility, solids removed from pump stations and lift stations, screenings and grit removed from the preliminary*

[22] Chapter 403, F.S addresses Environmental Control; Part I of the Chapter addresses Pollution Control
[23] Title 40, Chapter I (Environmental Protection Agency), Subchapter O - SEWAGE SLUDGE (Parts 501 - 503). Part 503 was published in the Federal Register (58 FR 9248 to 9404) on February 19, 1993, and became effective on March 22, 1993.
[24] The attractiveness of the biosolid to rodents, flies, mosquitoes, birds, or other organisms capable of transporting infectious agents.
[25] The EPA offers "A Plain English Guide to the EPA Part 503 Biosolids Rule" (https://www.epa.gov/sites/default/files/2018-12/documents/plain-english-guide-part503-biosolids-rule.pdf)

> *treatment components of domestic wastewater treatment facilities, or ash generated during the incineration of biosolids*.

The definition is consistent with industry practice and the federal interpretation of the term, which has focused on the bulk product from publicly owned treatment works (POTW) or wastewater treatment facilities (WWTF). Other than the wastewater residuals from onsite treatment and disposal systems (e.g., septic tanks and drainfields) that have been transported to a wastewater treatment facility for further treatment, Florida's definition for biosolids does not include domestic (residential) septage, which was historically managed by the Florida Department of Health, but is currently managed by the DEP.

Section 16 of the "Clean Waterways Act" of 2020 (Senate Bill 172) included significant regulatory provisions for biosolids. Section 403.0855, F.S.,[26] establishes legislative intent to regulate biosolids via permitting and thereby reduce the migration of nutrients into receiving water bodies. The legislation directed the DEP to adopt rules that required legislative ratification. The key requirement for a permit for the land application of biosolids is a minimum unsaturated soil depth of 2 feet between depth of the biosolids placed (if lower than the land surface itself) and the water table at the time of application. Also, biosolids may not be applied on soils that have a seasonal high-water table less than 6 inches from the surface or within 6 inches of the intended depth of biosolids placement, unless a department-approved nutrient management plan and water-quality monitoring plan provide reasonable assurances that application of biosolids at the site will not contribute to a violation of the state's surface water quality or groundwater standards. Any site receiving biosolids must be enrolled in the Department of Agriculture and Consumer Services (DACS)'s best management practices (BMP) program. Existing local government regulations regarding biosolids adopted before November 1, 2019, may remain in effect. Through its Clean Waterways Act, the State of Florida emphasizes that biosolids placement shall not impair receiving waterbodies via stricter standards for spatial separation.[27]

Two other Florida statutes apply to biosolids management. First, Subsection 373.811(4), F.S., prohibits the application of biosolids within the boundaries of a basin management action plan (BMAP) in effect for an Outstanding Florida Spring not otherwise in accordance with a previously approved nutrient management plan. The nutrient management plan establishes the rate of application for all biosolids, soil amendments, and sources of nutrients at the land application site.[28]

Second, and more significantly for this study, s. 373.4595, F.S., established the "Northern Everglades and Estuaries Protection Program" and various means to manage phosphorus loading to Lake Okeechobee.[29] Specifically, paragraph 373.4595(3)(b)16. requires that the DEP

> *"not authorize the disposal of domestic wastewater biosolids within the Lake Okeechobee watershed unless the applicant can affirmatively demonstrate that the phosphorus in the biosolids will not add to phosphorus loadings in Lake Okeechobee or its tributaries. This demonstration shall be based on achieving a net balance between*

[26] s. 16, ch. 2020-150, Laws of Florida
[27] These standards do not fully account for site-specific surface or groundwater hydrology or the rate of degradation for transported contaminants.
[28] s. 28, ch. 2016-1; s. 9, ch. 2023-169, Laws of Florida
[29] The Lake Okeechobee Watershed Construction Project (LOWCP) governed by the latter statute includes portions of the following counties: Palm Beach, Hendry, Glades, Martin, Highlands, Okeechobee, Osceola, Polk, and Orange (and the extreme southwest corner of St. Lucie).

phosphorus imports relative to exports on the permitted application site. Exports shall include only phosphorus removed from the Lake Okeechobee watershed through products generated on the permitted application site."

While in theory Class B biosolids could be land applied in south Florida and the Okeechobee basin, as a practical matter the restrictive provisions of paragraph 373.4595(3)(b)16, F.S., preclude such disposal. Consequently, biosolids from 11 south Florida counties must either be landfilled, incinerated, converted to Class AA biosolids, or exported from south Florida. [30] All four of these practices are conducted.

An important additional consideration to the Northern Everglades and Estuaries Protection Program is that the above prohibition does not apply to Class AA biosolids that are marketed and distributed as fertilizer products in accordance with agency rules.[31] This latter provision has proven to have an impact on the choices made by utilities whether to produce Class AA biosolids, and there is a clear trend to opt for Class AA, despite higher costs.[32]

Further, the statute provides a mechanism for part of biosolids management cost recovery for utilities in the 11 south Florida counties within the Okeechobee basin, provided that treatment and disposal is carried out by an approved alternative treatment methodology within areas designated as rural areas of opportunity pursuant to s. 288.0656, F.S. However, proceeds from such disposal fees are to be used solely for treatment of biosolids and not used for transportation or shipment.

To summarize Florida's recent regulatory changes, the 2020 Clean Waterways Act speaks to minimizing nutrient (and other) pollution from biosolids via ensuring greater physical space for passive diminution within unsaturated soils statewide while the water quality provisions Northern Everglades and Estuaries Protection Program focuses solely on the phosphorus impacts within in a single watershed.

Last, the 2023 Legislative session enacted Chapter 2023-293, LOF and created s. 403.0674, F.S.; establishing a biosolids grant program within DEP and (subject to appropriations) authorizing the department to provide matching grants to local governments for innovative biosolids projects that expand Class AA production, reduce the percentage of available nutrients and reduce residual CECs. Efforts to enact stricter regulations on land application of biosolids statewide have not advanced, in part because DEP and the Legislature seek information on the effectiveness of the rules put into place in 2021.[33]

Department of Environmental Protection Rules

The DEP regulates biosolids via Rule Chapter 62-640, F.A.C. Rule 62-640.100, F.A.C., outlining the department's intent: to regulate the management, use, and land application of biosolids as to ensure

[30] In response to the provisions of the Northern Everglades and Estuaries Protection Program, Class B biosolids application sites proliferated in Polk and Osceola counties outside the boundaries of the SFWMD.
[31] The label Class AA reflects EPA's and DEP's most stringent minimum requirements for land application. These are discussed in detail below.
[32] As Class AA has no restrictions on use and can be sold anywhere, hence the market area for distribution is greater.
[33] The grant program reflects the interests of the regional planning councils that adopted biosolids resolutions and the efforts of several advocacy organizations seeking to provide incentives to utilities to adopt technologies that reduce environmental impacts.

protection of the environment and public health; Rule 62-640.200, F.A.C., provides key definitions that in turn refer to the applicable federal definitions, which specify the standards and criteria (Appendix I)

In sum, the classes defined by Florida are derived from EPA's general outline related to reduction of pathogens, vector attraction, and thresholds for metals (and arsenic, a non-metal). The reductions in pathogens, etc., are generally achieved through conditioning, thickening, stabilization, dewatering, thermal conversion, drying, and other processes at the wastewater treatment plant.[34] In Florida, biosolids are typically aerobically digested, anaerobically digested, or lime stabilized for specific lengths of time to achieve Class B designation.[35] The following table generalizes these distinctions.

TABLE 3. SUMMARY OF CRITERIA BY BIOSOLIDS CLASS

Class	Pathogens	Metals*	Vectors	Land Application
B	Low levels of pathogens which die-off when applied to soils: Fecal Coliform: < 2 million Most Probable Number (MPN) per gram of dry biosolids	Limits for Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, and Zinc	>38% volatile solids reduction OR any 1 of 9 other options must be met (specified by EPA rule)	*Not approved* for home or garden use
A	Pathogens largely eliminated prior to application: • Fecal Coliform: < 1000 MPN per gram of dry biosolids; • Salmonella Sp.: < 3 MPN per 4g of dry biosolids	Limits for Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, and Zinc	>38% volatile solids reduction OR any 1 of 9 other options must be met (specified by EPA rule)	*Conditionally approved* for home and garden use
AA / A EQ	Pathogens effectively eliminated prior to application	As above for A	As above for A	*Approved* for home and garden use

Source: https://www.cambi.com/resources/blog/class-a-biosolids-and-the-future-of-biosolids-management/ (2021)

* Metals categories and allowable concentrations vary for disposal via landfilling or incineration, as does the specification for vectors. Class A is approved for home use subject to annual and cumulative loading rates for these contaminants.

Importantly, Class AA biosolids are exempt from nutrient restrictions for land application based on the higher levels of treatment required for metals and pathogens.[36] Biosolids must meet Class AA requirements to be used as fertilizer and the seller must have a state fertilizer license. All other biosolids that are land-applied must be placed only on a state-permitted application site that follows site-specific nutrient management plans (NMP) with phosphorus assessments, the nutrient of concern for algal blooms.[37] Per DEP rule, each of these land application sites requires a nutrient management plan, setback provisions, a groundwater depth provision, signage requirements, storage requirements, public access, grazing, harvesting restrictions, runoff provisions, and record-keeping and reporting requirements.[38]

House Bill 1309 (2021) ratified the rules that DEP had been preparing for the two years prior and had published on December 3, 2020, in the Florida Administrative Register, Vol. 46, No. 234, pages 5281-

[34] https://www.epa.gov/sites/default/files/2018-11/documents/emerging-tech-biosolids-management.pdf
[35] Florida DEP, Biosolids in Florida: 2013 Summary
[36] While Class AA is exempt from nutrient standards, increased composting of Class AA biosolids can result in significantly reduced content of plant available (leachable) nutrients.
[37] https://edis.ifas.ufl.edu/publication/SS634
[38] https://www.florida-stormwater.org/assets/MemberServices/Conference/AC19/02%20-%20Frick%20Tom.pdf

5297.[39] Per the Legislature, the rules proposed by the Department of Environmental Protection pursuant to s. 403.0855(2), F.S, are exempt from review and approval by the Environmental Regulation Commission.[40]

Regional Planning Councils

Florida's Regional Planning Councils (RPCs) are not regulatory bodies. They do, however, establish regional policies that their constituent local governments' local comprehensive plans (which do carry the force of law) are to be consistent with, if not further. Nine of the ten RPCs have adopted resolutions that seek the following two objectives:

1. The State of Florida and its local governments prioritize the reduction and eventual elimination of the land application of human wastewater biosolids; and
2. The State of Florida establish a Pilot Projects Program for funding local utilities to implement new state of the art wastewater treatment technologies to improve recovery and afford more efficient use of human wastewater biosolids resources.

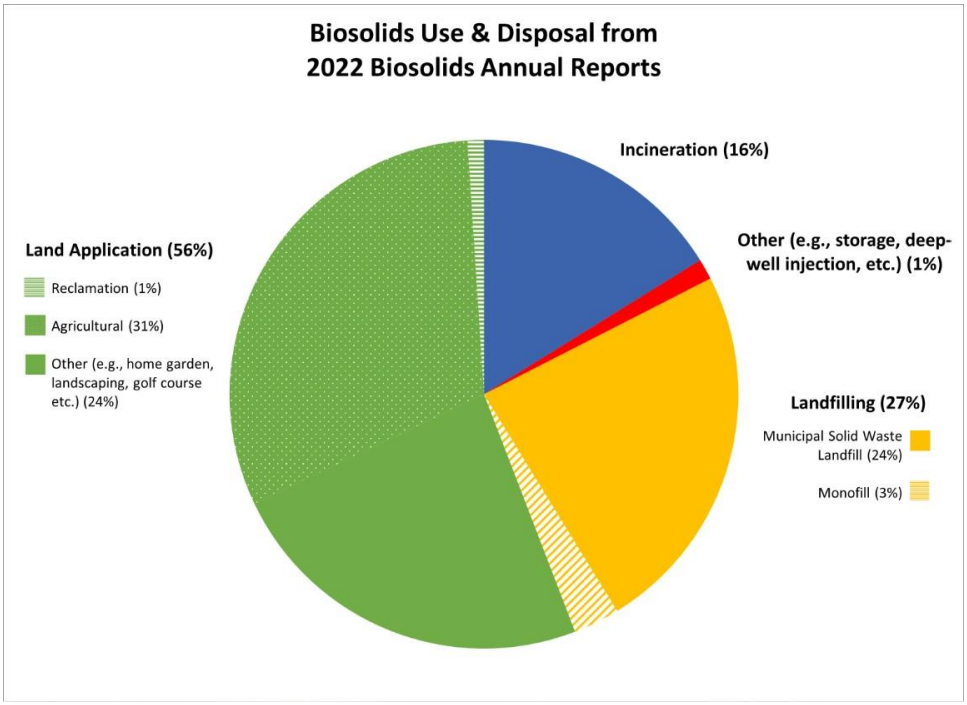
The second of these two objectives has been met in principle by s. 403.0674, F.S. However, the first of the objectives is regulatory in nature and additional State action is needed to further the Clean Waterways Act and expand the watershed protection provisions of the Northern Everglades and Estuaries Protection Program to other watersheds. This report's recommendations are consistent with those of the RPCs.

[39] Section 1, Chapter 2021-153, Laws of Florida.
[40] The exemption ensured that the rule provisions could not be challenged under Chapter 120, F.S., proceedings.

State of Knowledge

The following section summarizes the general operational framework of land application of biosolids in Florida. For comparison only, the following two charts describe the recent disposition and trends of biosolids *nationally.*[41] Both derive from wastewater facility program reports but offer differing levels of detail.

FIGURE 1. US BIOSOLIDS USE AND DISPOSITION, 2022



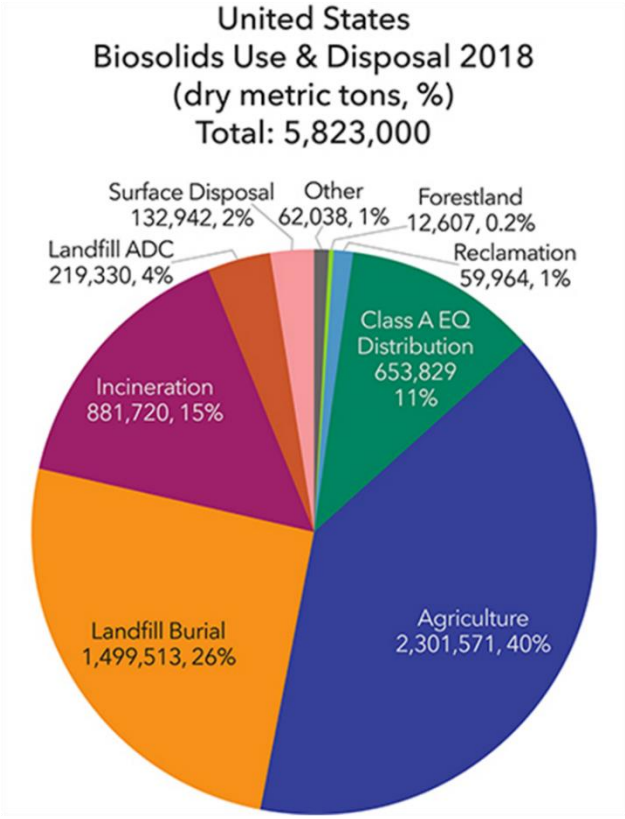
Source: https://www.epa.gov/biosolids/basic-information-about-biosolids

Between the 2021 and 2022 summaries provided by the EPA, the percentage of biosolids being land applied increased from an estimated 43% to 56%, the landfill share declined from 42% to 27% and the share being incinerated increased by 2% (**Figure 2)**.

While comprised of slightly older data, **Figure 2** presents more detailed information regarding the distribution of biosolids again at the national level. The categories are not fully compatible with **Figure 2,** but if complete, these data do reflect a trend towards less incineration and landfilling and an increase in land application. The EPA classification A EQ is similar to Florida's Class AA.

[41] Because of monitoring regulation there is a data lag of nearly two years for most biosolids reporting, i.e., Fiscal Year 2022-23 biosolids data are not transmitted to EPA and compiled until FY 2024 and published in summary form until FY 2025. Reliant on the same data, the Florida DEP is on approximately the same schedule.

FIGURE 2. US BIOSOLIDS USE AND DISPOSITION, 2018



Source: National Biosolids Data Project, https://www.biosolidsdata.org/national-summary

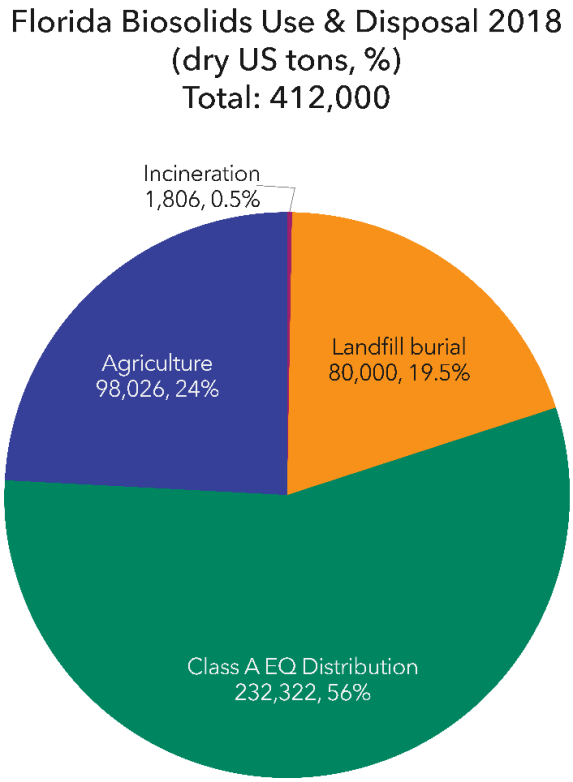
If accurate, a key difference between the data in 2018 and 2021 is the increase in land application in general (from 51% to 56%) but with a marked increase in Class A EQ (home and garden) from 11% to 24% but a decline in agricultural use from 40% to 31%.

Deep well injection is not permitted in Florida; at the national level landfilling and land application are the primary means of disposal while incineration is used at a rate of about one-third of each of the two primary methods of disposal.

For comparison, **Figure 3** reflects historical estimates of the disposition of biosolids in Florida.[42] In 2018, an estimated 24% of biosolids were land-applied (i.e., as Classes B and A) while an estimated 56% of all biosolids were converted to Class AA for landscaping, fertilizer, etc., in sum an estimated 80% of all biosolids were land applied. Incineration was negligible in contrast with other states. While the percentage converted to Class AA is consistent with DEP's estimates, the total volume estimated by the National Biosolids Data Project (412,00 dry tons) is 21% greater than that stated by DEP.

[42] National Biosolids Data Project

FIGURE 3. FLORIDA BIOSOLIDS USE AND DISPOSITION, 2018



Source: https://www.biosolidsdata.org/florida

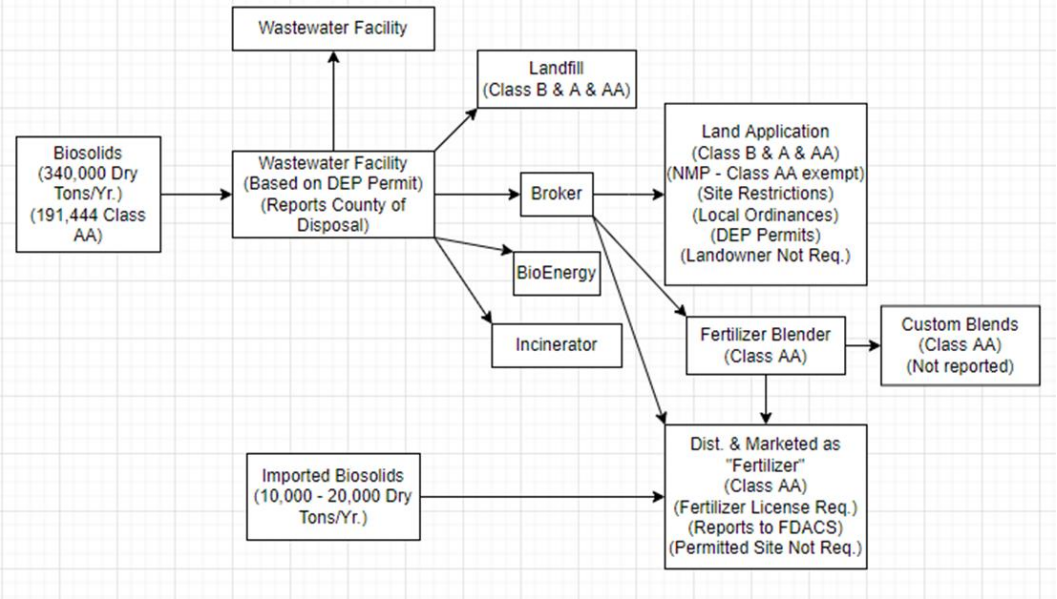
Per the Florida DEP, **Figure 4** summarizes the multiple pathways for biosolids. Of note, the figure reflects 340,000 dry tons rather than the 412,000 dry tons reported above for 2018. However, the allocation of approximately 56% to Class AA remains (191,000 tons). Up to 20,000 tons of dry biosolids are imported from out of state and incorporated into fertilizer products manufactured within Florida. This amount rectifies part of the discrepancy between the Biosolids Project and DEP volumes.

According to the National Biosolids Data Project,[43]

> "The total of 232,322 dry U. S. tons of Class AA EQ material includes bulk alkaline stabilized and other products, and the total is for the finished products combined, not the wastewater solids going into the process. This somewhat inflates the biosolids totals for the state; for example, up until 2014, a large N-Viro facility near Tampa produced a product that was as little as 15% biosolids and mostly coal ash. But this was a rare anomaly, and that particular facility is no longer operating. For 2016, FL DEP reported 191,344 dry tons of final Class AA biosolids distributed (2% went out of state; the rest was used in FL), so the amount of Class AA has been increasing in recent years. In 2016, 5 out-of-state facilities sent nearly 10,00 dry tons into Florida (e.g. Milorganite)."

43 https://static1.squarespace.com/static/601837d1c67bcc4e1b11862f/t/61800f1ffdde793c3105d59b/1635782433317/FL_BiosolidsDataSummary_NBDP_20211101.pdf

FIGURE 4. GENERALIZED MOVEMENT OF BIOSOLIDS IN FLORIDA (DEP)



Source: DEP

Table 4 summarizes the recent information available via the reports to EPA (through 2021) prepared by wastewater treatment facilities (publicly owned treatment works). The reported volume of biosolids generated by these facilities has declined significantly, 39% over the four-year period. It is emphasized that there are often lags in both reporting by the facilities and data collection and summarization by the EPA. Further, the data in Table 3 reflect only the larger public facilities, and not all generators which can include smaller private and municipal utilities. This is corroborated in part by the National Biosolids Data Project which reports that its numbers are based on approximately 75% of the total volume of wastewater generated and treated.

TABLE 4. RECENT EPA BIOSOLIDS MANAGEMENT DATA, FLORIDA

	2018	2019	2020	2021
Number of Facilities	117	119	118	122
Total Biosolids Generated	282,205	238,490	193,026	171,946
Biosolids Land Applied	222,903	162,969	124,794	91,751
Biosolids Surface Disposal	241	1,864	-	-
Biosolids Incinerated	-	-	-	-
Biosolids - Other	59,061	70,143	74,108	80,825

Source: EPA, Biosolids POTW, 2018-2021

Notes: Quantities disposed are not equal to amount generated due to reporting discrepancies. Data reported are for only those publicly owned treatment works that provide data to EPA timely.
"Other" would include landfilling.

Of importance, despite no significant change in the number of reporting facilities, Table 4 denotes a dramatic 59% decline in land application with a significant 37% increase in "Other" disposal – primarily

the conversion to and alternative use of Class AA biosolids.[44] Recent reporting via the Florida Water Environment Association suggested a decline in the number of permitted application sites from ~140 to ~90[45] between 2018 and 2023 and that typical 5-year permits from DEP have been allowed to lapse and not be renewed. It is broadly understood that Class B and Class A land applications will continue to decline, while recent regulations (including the 2020 Clean Waterways Act) and financial incentives (as made available by HB 1405, 2023) will drive expanded conversion of biosolids to Class AA.

Biosolids Production Data

There is no single source of consistent information about biosolids production that can be corroborated. The US Environmental Protection Agency receives reports from utilities and local governments operating wastewater treatment facilities exceeding a permitted capacity threshold; the Florida Department of Environmental Protection receives similar reports for facilities that have state permits; and the National Biosolids Database Project gleans information from multiple sources. As an example, TABLE 5 and TABLE 6 provide examples of some reported data.

TABLE 5. RECENT EPA BIOSOLIDS DATA, FLORIDA, BY CLASS

EPA Class	2018	2019	2020	2021
Class A	107,279	45,165	65,895	54,440
Class A EQ*	59,136	31,422	43,844	76,320
Class B	110,938	130,373	78,182	86,649
N/A	19,747	31,767	20,909	27,290
Totals	297,100	238,727	208,830	244,699

Source: EPA, Biosolids POTW, 2018-2021

Notes: Quantities in Table 5 do not match those of Table 4.

* EPA Class A EQ is equivalent to Florida's Class AA

TABLE 6. SELECT FLORIDA BIOSOLIDS PRODUCTION DATA, BY SOURCE

Year	Land Applied	Alternative Disposal	Reported Total	Data Source
2004	249,000	51,000	300,000	NBDP
2014			300,000	DEP
2018	330,348	81,806	412,154	NBDP
2018	277,353	19,747	297,100	EPA
2019			340,000	DEP
2021	217,409	27,290	244,699	EPA

Source: Study database

In the above table, the reported total production varies by 40,000 tons between two sources of information. In 2018, the disparity is 115,000 tons; and in 2021, the reported total from a single source (EPA) is less than that for 2018, despite population growth.

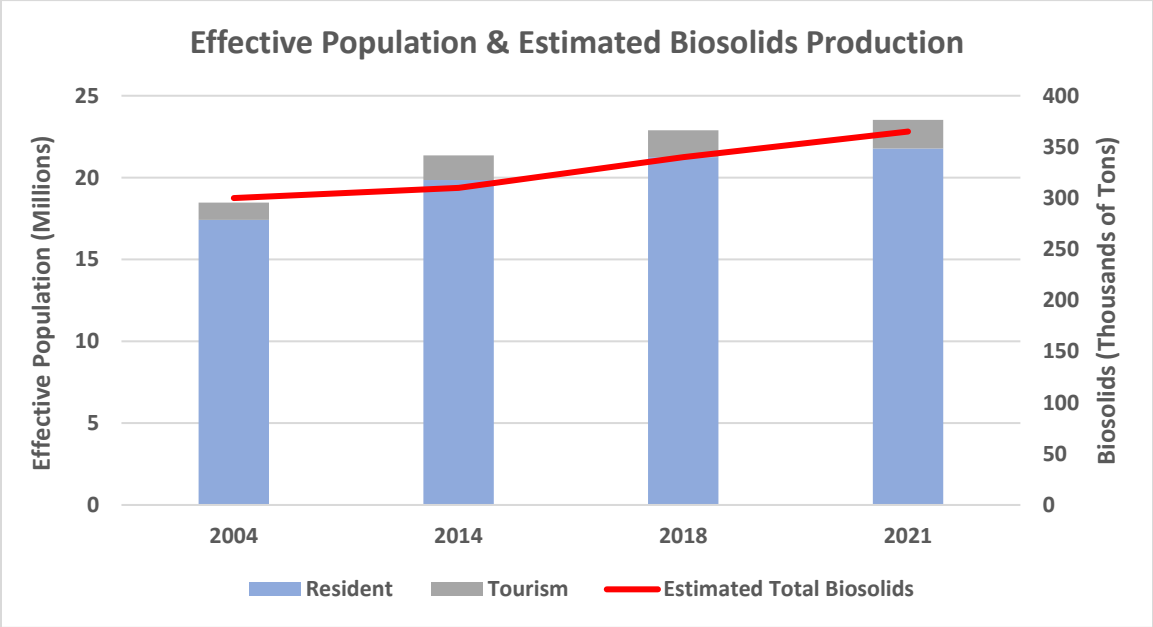
[44] Table 4 reflects a decline in reported production, which is attributable to incomplete reporting and not a reduction in generated material.

[45] The current number of active sites is believed to be 85 (FWEA).

The sources of disparity include incomplete reporting by utilities, a component of smaller utilities that fall below the EPA reporting threshold, and the recordkeeping and estimation conducted by the utilities themselves. Biosolids data reporting at the federal level are primarily about the concentrations of heavy metals and pathogens, and less about the quantities themselves.

Rather than attempting to reconcile these disparities FIGURE 5 offers an estimate based on the coarse historical data and the more reliable estimates of population and tourism that define an effective population for projecting the production of biosolids (Appendix A). Because of the data limitations identified above, the above chart likely describes an underestimate.

FIGURE 5. ESTIMATED BIOSOLIDS PRODUCTION



Source: Appendix A

While this report updates biosolids disposal data accurately through 2021, for purposes of discussion it had been estimated by DEP that Florida has been producing about 340,000 dry tons of biosolids per year over the past decade. Historically, approximately one-third of this amount has been land-applied (as Class B),[46] one-third distributed and marketed as fertilizer,[47] and the remaining one-third is landfilled.[48] In sum, about two-thirds of biosolids produced are land applied in some form. According to the DEP, an additional 10,000 to 20,000 dry tons of fertilizer pellets are routinely imported from out-of-state wastewater treatment and processing facilities.[49] DEP has cautioned, however, that there are errors in its estimations due to the use of self-evaluation forms.

In summary, biosolids production is inextricably linked to wastewater generation, and wastewater generation is in turn driven by population. Florida's population continues to grow, and wastewater (and therefore biosolids) generation can be assumed to increase roughly linearly with population and

[46] Most biosolids are surface-applied either as dewatered "cake" biosolids or as liquid biosolids.
[47] https://www.florida-stormwater.org/assets/MemberServices/Conference/AC19/02%20-%20Frick%20Tom.pdf
[48] Frick, 2019
[49] DEP, 2018.

tourism. Appendix A establishes the population and wastewater generation bases for biosolids production in Florida.

Biosolids Management

With regard to the dominant forms of biosolids management, the factors contributing to the choice of land application versus local (or regional) landfilling include transportation costs (i.e., distance), rising energy costs that affect both biosolids treatment options and transportation, the adoption of restrictive county ordinances, the enactment of restrictive legislation for particular watersheds, and the 2010 revisions to Chapter 62-640, FAC.[50] Further revisions pursuant to House Bill 1309 (2021), signed into law on June 21, 2021, and ratifying a proposed biosolids rule (Chapter 2021-153, Laws of Florida) are discussed below.

Permits and permit renewals vary annually, but there remain about 140 permitted Class B biosolids land application sites in Florida covering more than 46,000 acres.[51] The number of sites continuing to receive Class B biosolids has, however, declined. Almost all land application sites in Florida grow hay crops or are pastures, however sod farms can also use biosolids and citrus groves used biosolids in the past.

With respect to nutrients, landscape loadings can be estimated. For example, in 2013, for the estimated 111,000 land applied tons (Class B), there was a coarse average of 2.42 dry tons of biosolids applied per acre with an estimated total nitrogen concentration of 5.27% and an estimated total phosphorus content of 2.30% (by weight).[52] This application rate implies a total of 255 lbs per acre of total nitrogen (i.e., about 11.7 million lbs added to the Florida landscape) and 111 lbs per acre of total phosphorus (i.e., about 5.1 million lbs). Of concern to this study is whether these supplemental quantities of nutrients are in excess of crop demand and whether they are applied in impaired watershed, exacerbating known water quality problems.

According to DACS, of the approximately 155,200 tons of nitrogen applied in fertilizers across the state, 83% (128,900 tons) was applied to farms. Of the 46,500 tons of phosphorus, 87% (40,630 tons) was applied to farms.[53] The above estimates of nutrients associated with land applied Class B biosolids (5,850 tons of nitrogen and 2,550 tons of phosphorus) represent 5% and 6% of these nutrients, respectively. In sum, Class B land applied biosolids represent a small fraction of nutrients applied to farmland at the state level. This percentage belies, however, the locations and limited acreages to which it is applied. Further, these estimates exclude the contribution of nutrients from Class AA, which are significant.[54]

Critically, biosolids consists of partially decomposed domestic waste, rich in both organic content and key macronutrients, including nitrogen and phosphorus. As such, the resource is potentially valuable for

[50] The rule changes in 2010 were largely in response to the 2007 updates to Title 40, CFR, Part 503 - Standards for the Use or Disposal of Sewage Sludge, that apply to septage management facilities treating more than 10,000 gpd, monthly average or greater than 20,000 gallons in a single day. The rule also addressed facilities using biosolids for compost production, and biosolids products generated outside the state of Florida.
[51] DEP, 2018
[52] DEP, 2014, Biosolids in Florida: 2013 Summary
[53] IFAS Publication #ENH1277, 2017.
[54] The concentrations of nutrients in uncomposted Class AA are similar to that of Class B. The concentrations of nutrients in highly composted Class AA (Class AA EQ) are roughly 20% of that of Class B. The share of highly composted vs uncomposted Class AA biosolids is not known with accuracy, although data are available for select counties.

its nutrient content, as an offset for the use of synthetic fertilizers (nitrogen in particular), and as a soil amendment to improve water retention, nutrient retention, and the soil biota as a whole. There are about 39 facilities producing Class AA in Florida with 192,879 dry tons distributed and marketed within the state and 26,717 dry tons distributed and marketed outside the state (219,596 total dry tons Class AA).[55]

While relatively high in caloric value, biosolids also have high moisture content and as a result only nominal quantities are incinerated. According to the DEP's 2014 summary, no biosolids have been reported burned since the last two major municipal incinerators closed in the 1990s. However, that report mentioned the burning of biosolids as fuel for waste-to-energy (WTE) facilities and for one cement kiln. New technologies may present alternative paths to the disposal of biosolids that result in less pollution and cost less and thereby provide societal and economic benefits for the public and for utilities customers. Alternative technologies for biosolids processing observed in Florida and elsewhere include gasification, supercritical water oxidation, anaerobic digestion, and other WTE facilities.[56] None of these alternatives has been deployed at any significant scale in Florida.

For the biosolids disposed in landfills, there are two components: (1) that portion which is landfilled with other municipal waste and (2) that portion has been historical use as daily "cover" by blending with soil to enhance conditions for growing cover vegetation. Depending on concentrations of metals and other toxics, landfilling may be a necessary option. Advantages of landfilling include use of less area for disposal and increased biogas (methane) production — where effectively captured, and generally reduced disposal costs. Landfilling does eliminate the opportunity for reuse, increases the costs for site closure, and may increase the risk of groundwater contamination from leachate where not well-managed. Disposal in landfills may exacerbate site-specific societal impacts including odors, traffic, and air quality.

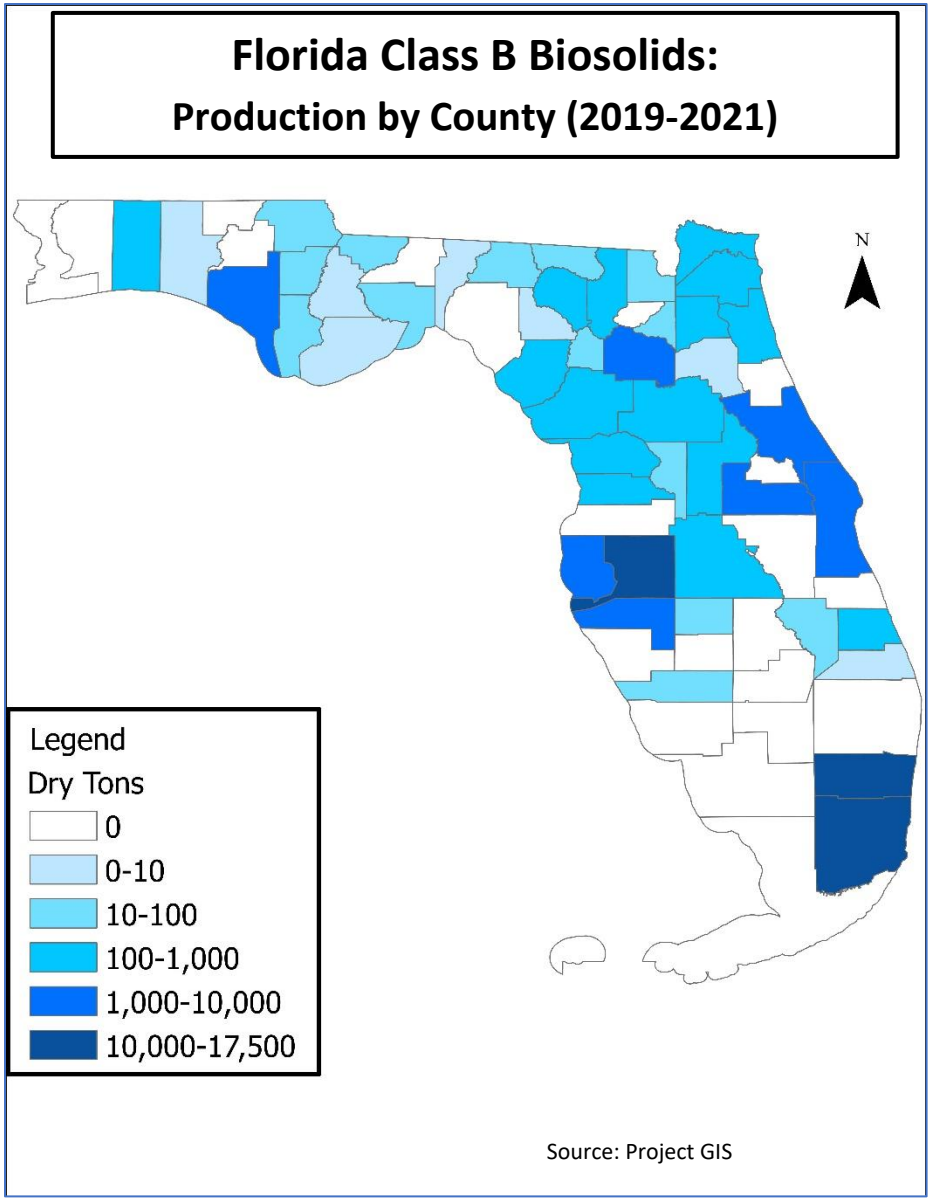
- Florida relies on landfilling and land application of Class B biosolids and conversion of the remainder to Class AA, which is now the dominant means of disposition.
- Alternatives, especially in the broad class of waste-to-energy technologies, are not widely used.
- The share of biosolids being converted to Class AA is increasing. This trend reduces some of the more noxious aspects of biosolids management but results in distributing the resource across more of the landscape, regardless of its nutrient content or the presence of CECs.[57]

Biosolids Generators

There are documented differences among counties that produce biosolids and those that receive biosolids, regardless of the class of material. **FIGURE 6** and **FIGURE 12** detail the county sources and average volumes (by range) of Class B and Class AA biosolids, respectively. Multiple counties produce both classes.

[55] Frick, 2019
[56] DEP, 2018.
[57] While Class AA products are unregulated as to distribution, this does not equate haphazard application at excessive rates. There are significant costs to users of Class AA associated with purchasing, trucking and spreading of the material. The economics of agricultural applications would dictate that none is applied more than is necessary, especially where nutrients are concerned. The focus for some applicators is for improving soil health in general, rather than providing nutrients only.

FIGURE 6. ANNUAL AVERAGE CLASS B BIOSOLIDS PRODUCTION IN FLORIDA (2019-2021)

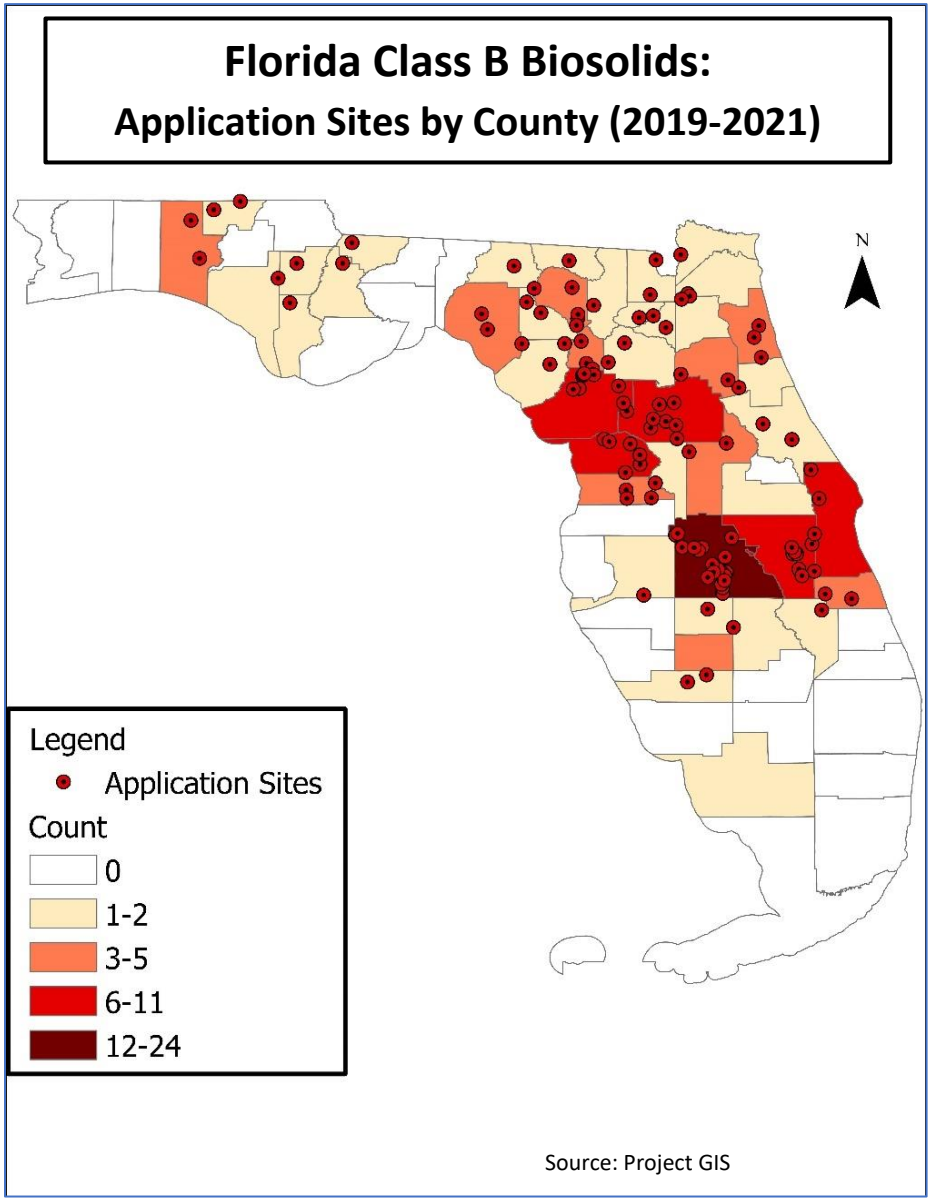


Class B Production: Between 2019 and 2021, 48 counties in Florida produced an annual average of Class B biosolids ranging between 1 to more than 17,400 dry tons. More specifically, of those listed 36 counties produce an annual average of less than 1,000 dry tons of Class B biosolids annually. Of the ten producing more, 2 counties produce between 1,000 and 2,000 dry tons, four counties produce between 2,000 and 5,000 dry tons, one produces between 5,000 and 10,000 dry tons, one produces between 10,000 and 15,000 dry tons and two produce more than 15,000 dry tons annually. The total volume generated by the other 19 counties in Florida is about 11,000 tons (more than 13% of the State's total); these average less than 1,000 tons annually each.

Counties that produced over 2,000 dry tons annually include Broward (17,406), Miami-Dade (16,243), Hillsborough (10,356), Orange (8,777), Bay (3,310), Volusia (2,819), Brevard (2,418), and Pinellas (2,137).

In addition to their respective volumes of generated Class B biosolids, these eight counties collectively produce 76% of the state's total annual production of Class B biosolids for which there are records of transfer.

FIGURE 7. NUMBER OF CLASS B BIOSOLIDS APPLICATION SITES BY COUNTY IN FLORIDA



Class B Application Sites: Counties vary significantly in terms of whether they receive biosolids at all and the number of recipient sites within.

There were a total of 130 biosolids land application sites in Florida recorded in the study between 2019 and 2021. However, only 85 of these sites have actively applied Class B biosolids.

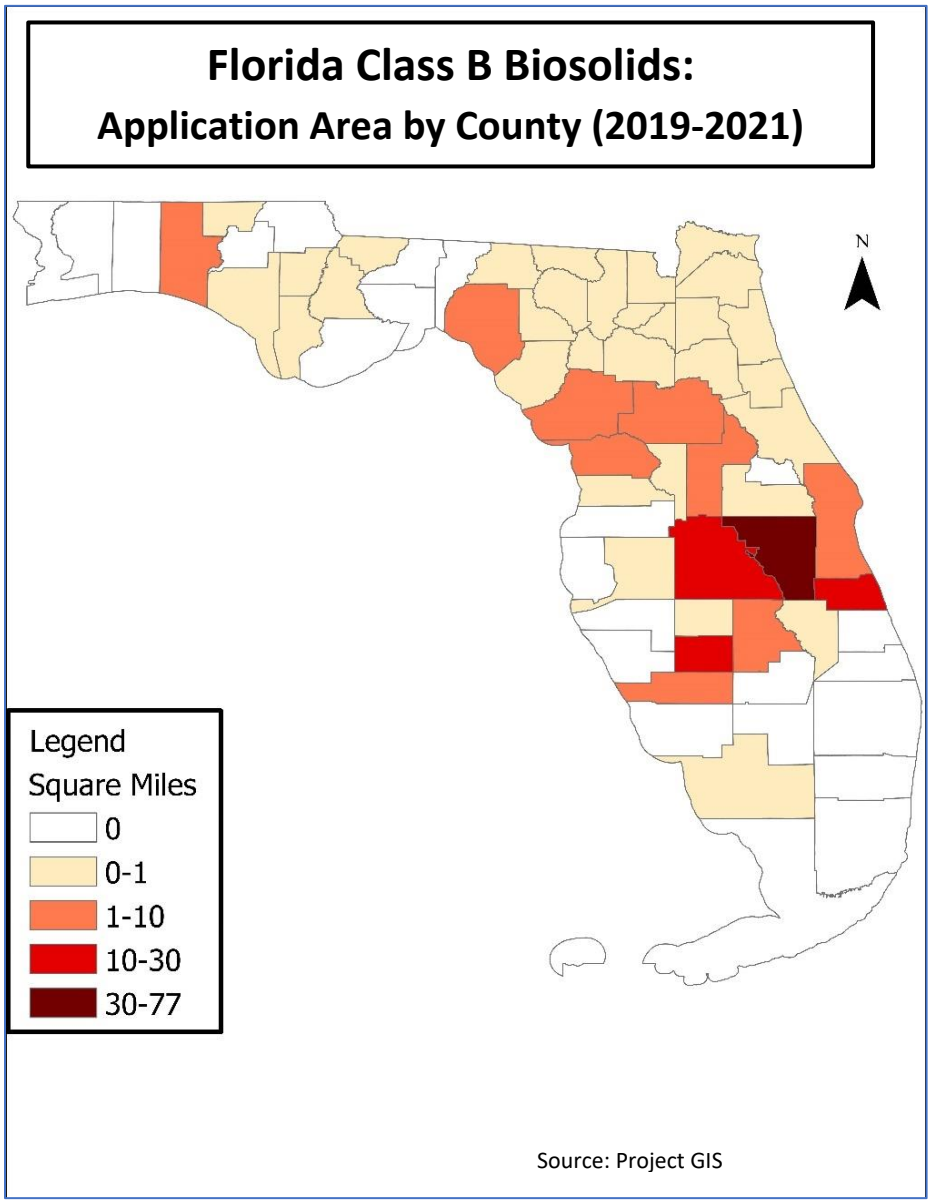
Most Class B biosolids land application sites are located in central and northern Florida. Throughout Florida, there are 44 counties with a permitted Class B land application site. Of the counties with a Class B land application site, 37 are active. Counties with the most land application sites include Polk (24), Levy (11), Osceola (9), Marion (8), Citrus (7), Brevard (6), Suwannee (5), and Indian River (4).

While there are land application sites in Polk and Osceola counties, these are largely outside the boundaries of the Lake Okeechobee Watershed Construction Project and the applicable standards under s. 373.4595, F.S.

Note that Collier County is recorded with between 1 and 2 application sites. Collier County is not within the Okeechobee Basin, for which the standards for land application under Chapter 373, F.S., apply.

Between 2019 and 2021 the average annual volumes of Class B biosolid land applications across the active application sites ranged from less than 1 dry ton to 61,100 dry tons.

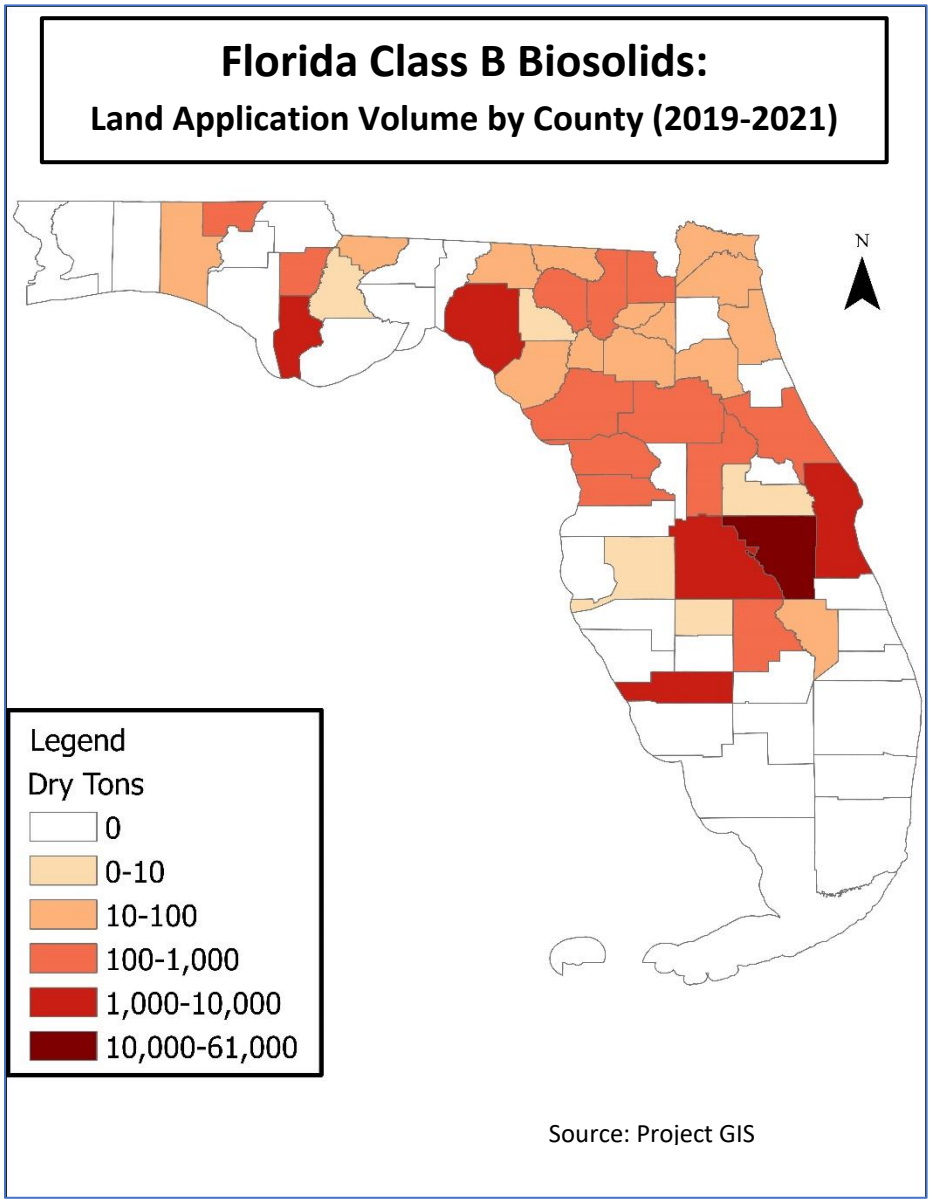
FIGURE 8. AREA OF CLASS B BIOSOLIDS APPLICATION SITES BY COUNTY IN FLORIDA



Class B Application Area: County-level Class B biosolids land application site areas range from less than 4 acres to 76 square miles. Counties with more than five square miles of active Class B biosolids land application sites include Osceola (76.2 sq. mi.), DeSoto (16.2 sq. mi.), Indian River (13.8 sq. mi.), Polk (12.9 sq. mi.), and Charlotte (8.1 sq. mi.). Osceola and DeSoto counties feature extensive acreage in improved pasture.

Note: Collier County is recorded with between 0 and 1 square miles of land application area. Despite being in South Florida Collier County is not within the Okeechobee Basin, for which strict standards for biosolids land application apply.

FIGURE 9. CLASS B BIOSOLIDS ANNUAL APPLICATION VOLUMES IN FLORIDA



Application Volume: Three-year total county-level Class B biosolid land applications ranged from less than 8 to 194,148 dry tons between 2019 and 2021. There are 34 counties applying between 0 to 50,000 dry tons and one county applying more than 150,000 dry tons of Class B biosolids on land.

Counties that have applied an average of more than 1,000 dry tons annually of Class B biosolids applied between 2019 and 2021 include Osceola (61,111), Polk (6,190), Brevard (3,603), Gulf (2,991), Charlotte (2,590) and Taylor (1,570).

The land belt from Hillsborough County to Brevard County represents a unique concentration of the land application of biosolids and was a focal point for subsequent review of potential environmental justice concerns and water quality impacts.

Levy and Marion counties also present a consolidated region for study, especially given the water resources of the area, which are dominated by springs.

The land application of Class B biosolids in Florida fluctuated from 87,933 dry tons in 2019 to 81,381 in 2020 but rose to 82,630 dry tons in 2021. This amounts to about a 6% decrease in the land application of Class B biosolids between 2019 to 2021.

FIGURE 10. CLASS B BIOSOLIDS APPLICATION SITES WITHIN USGS HYDROLOGIC UNIT CODE, LEVEL 12

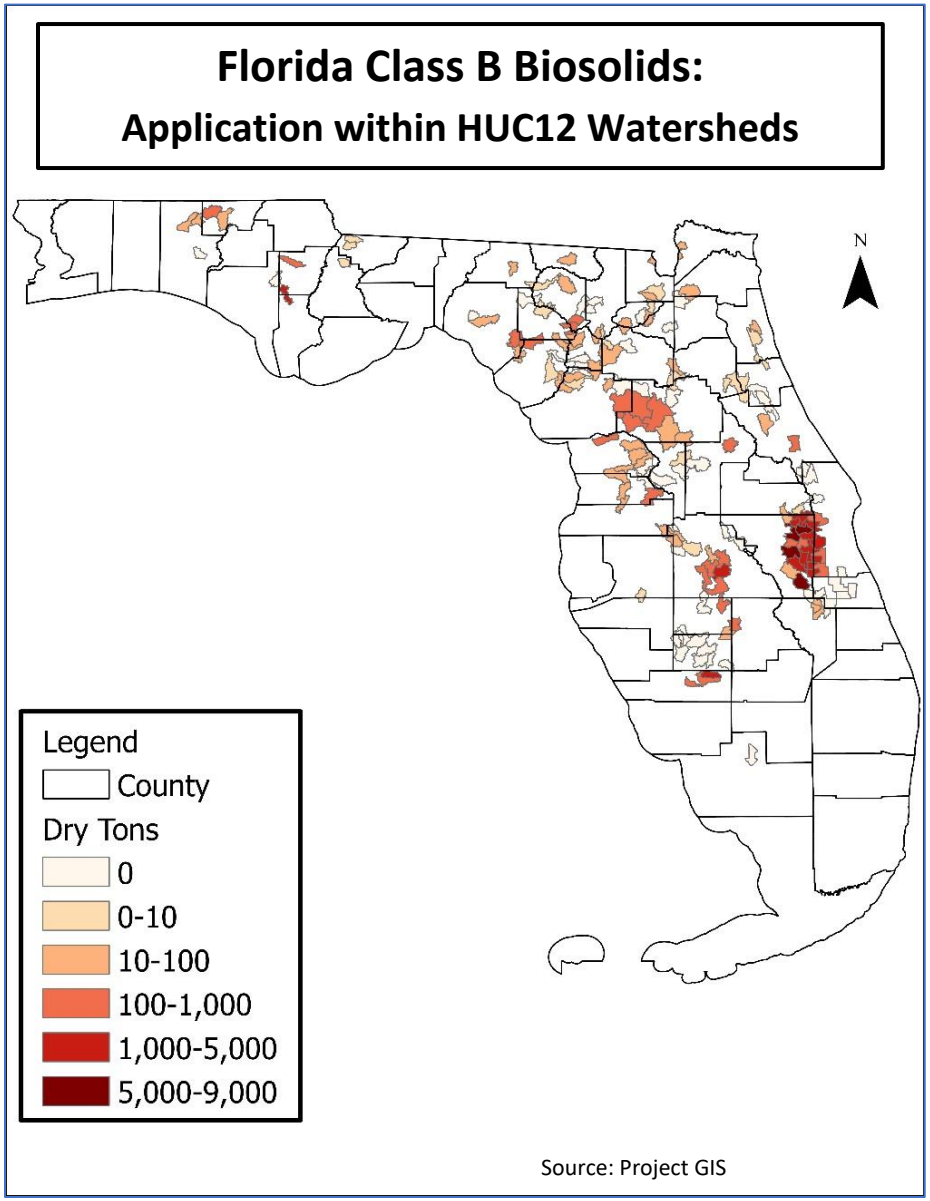
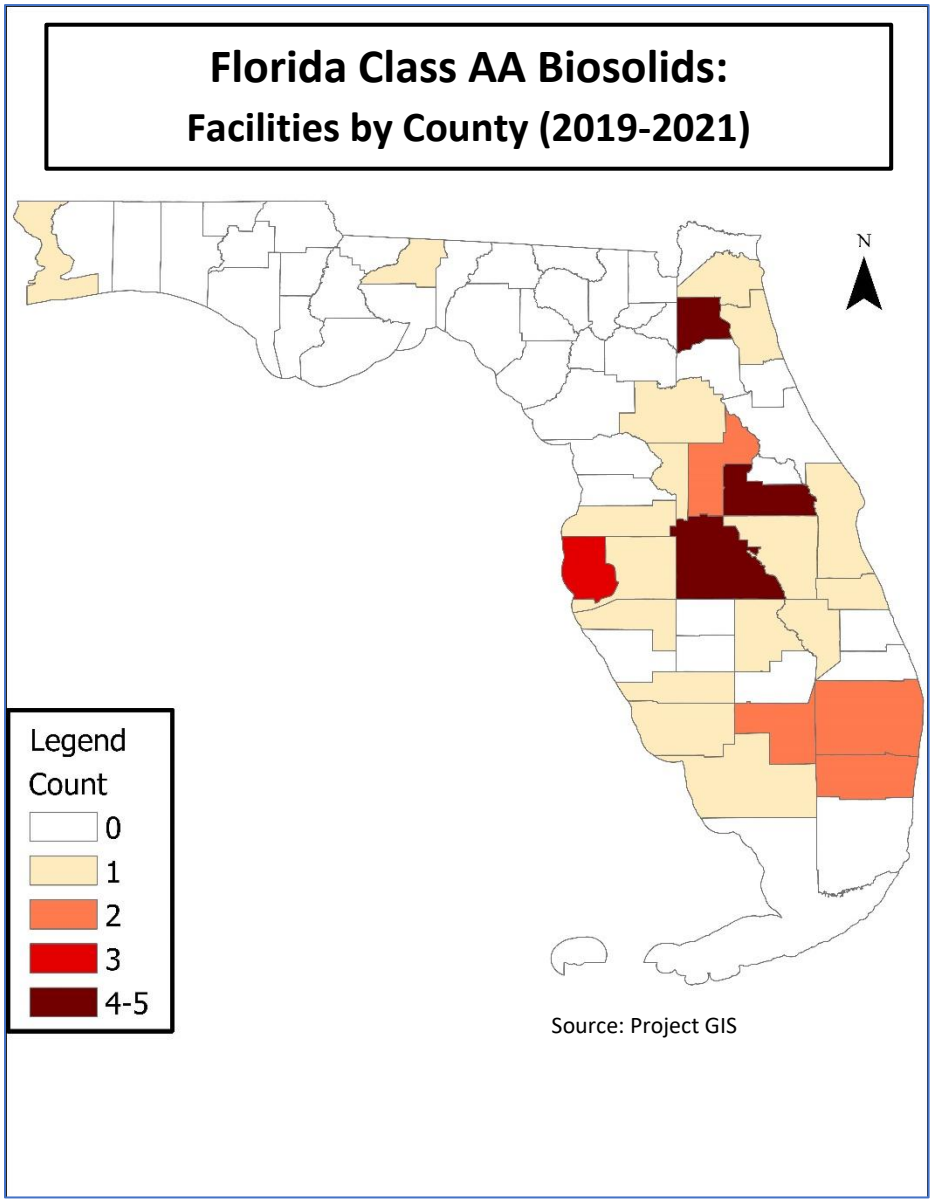


FIGURE 10. associates the three-year volumes of biosolids of permitted land application sites within their respective Level 12 HUCs ("sub-watersheds").

Consistent with the expected outcome of the provisions of s.373.4595, F.S., the number of impacted HUCs in eastern Osceola County (and extending hydrologically into western Brevard County) is apparent. The volumes of applications of biosolids are less, but the pattern of locations outside the northern extent of the SFWMD is also evident in central Polk County.

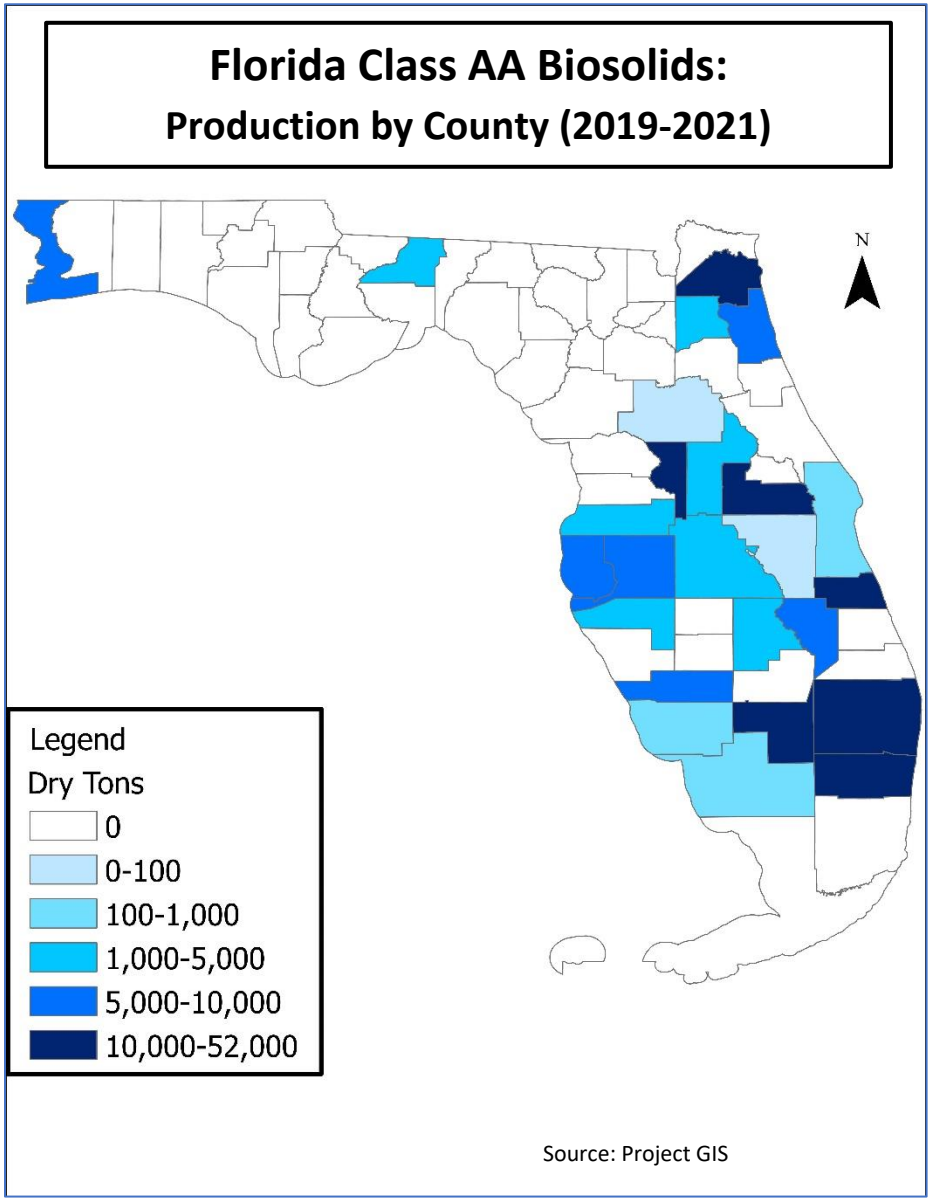
The remaining significant allocations of biosolids are within three HUCs: (1) eastern Levy County and western Marion County; (2) northern Gulf and southern Calhoun counties, and (3) southeastern Taylor, northwestern Dixie, and southwestern Lafayette counties.

FIGURE 11. CLASS AA BIOSOLIDS PRODUCTION FACILITIES IN FLORIDA



Class AA Facilities The DEP monitors facilities producing Class AA biosolids, which are distributed as fertilizer and not tracked as to locations of applications. FIGURE 11 identifies the numbers of facilities within those counties producing Class AA biosolids. Polk, Orange and Clay counties have the largest numbers of individual production sites. The data include a range of facility types such as WWTPs (Immokalee WWTP), compost facilities (Compost USA), and Pelletizers (Palm Beach Pelletizer).

FIGURE 12. ANNUAL AVERAGE CLASS AA BIOSOLIDS PRODUCTION IN FLORIDA



Class AA Production: The amount of Class AA biosolids produced in Florida increased from 206,153 dry tons in 2019 to 248,665 dry tons in 2020 then dropped to 228,111 dry tons in 2021. This amounts to almost an 11% increase in Class AA production from 2019 to 2021.

There were 25 counties producing Class AA biosolids in Florida between 2019 and 2021, ranging between 130 and 154,864 total dry tons for the three-year period.

Twelve counties produced less than 5,000 dry tons annually, six counties produced between 5,000 and 10,000 dry tons annually, two counties produced between 20,000 and 30,000 dry tons annually, one county produced 30,000 to 40,000 dry tons annually, and one produced more than 50,000 dry tons annually. Major producers (greater than 10,000 dry tons) of Class AA biosolids include Sumter County (52,600), Orange County (36,400), Palm Beach County (21,500), and Indian River County (21,000). Sumter County receives biosolids from other counties for processing into Class AA.

Production of Class AA biosolids does not equate to local consumption or use. While some counties market and distribute internally others do not. For example, Lee County initially marketed "OrganicLee®" to agricultural enterprises in Lee and Hendry counties but has since expanded to Southwest Florida.

Class B Biosolids Transfers: The land application of Class B biosolids remains a significant management choice, with implications for both the sending and receiving counties. Distance translates into costs for managing biosolids and also defines the directionality of environmental impacts. According to the study's Biosolids Matrix (**Appendix C**), a number of key average annual inter-county movements by the major generators of biosolids may be gleaned:

- Osceola County received more than 61,100 dry tons via inter-county transfers of the nearly 84,000 total tons transferred. The next largest inter-county transfer was to Polk County with about 6,100 tons received.
- Broward County transported 16,144 dry tons to Osceola County, 1,006 dry tons to Brevard County and 262 dry tons to Polk County.
- Miami-Dade transported 13,716 dry tons to Osceola County, 1,362 dry tons to Brevard County, 766 dry tons to Polk County, and 399 dry tons to Charlotte County.
- Hillsborough County transported 7,205 dry tons to Osceola County, 1,687 dry tons to Charlotte County, 1,480 dry tons to Polk County, 160 dry tons to Brevard County and 4 dry tons within its own jurisdiction.
- Orange County transported 8,416 dry tons to Osceola County, 215 dry tons to Brevard County and 146 dry tons to Lake County.
- Pinellas County distributes broadly: 925 dry tons to Polk County, 566 dry tons to Osceola County, 355 dry tons to Hernando County, 255 dry tons to Highlands County and 35 dry tons to Brevard County.
- Bay County transported 2,411 dry tons to Gulf County and 899 dry tons to Calhoun County.
- Volusia County transported 2,253 dry tons to Osceola County, 351 dry tons to Brevard County, 17 dry tons to Suwannee County and 198 dry tons within its own jurisdiction.
- Brevard County transported 2,310 dry tons to Osceola County and 107 dry tons within its own jurisdiction.

TABLE 7. SELECT BIOSOLIDS TRANSFER DISTANCES

ORIGIN	DESTINATION	TONS/ YEAR	APPROX. DISTANCE (mi)
Miami-Dade	Osceola	13,716	223
	Brevard	1,362	210
Broward	Osceola	16,144	211
	Brevard	1,006	198
Hillsborough	Osceola	7,205	103
	Charlotte	1,687	102
	Polk	1,480	43
Orange	Osceola	8,416	45

Source: Biosolids Matrix, Appendix C; https://www.distance.to/

Per TABLE 7, among eight of the largest Class B biosolids transfers, only two are less than 50 miles, three are about 100 miles, and three are more than 200 miles, which may be a practical limit as these distances impose significant costs for land application options. Were distances (and therefore costs) larger among these, other biosolids management strategies may be more competitive.

Counties that have received via inter-county transfer an annual average of more than 1,000 dry tons of Class B biosolids between 2019 and 2021 include Osceola (61,111), Polk (6,190), Brevard (3,603), Gulf (2,991), Charlotte (2,590) and Taylor (1,570). These six counties comprise 93% of the state's volume of inter-county transfers of Class B biosolids. In sum, of 44 counties with permits to receive Class B biosolids (not all active), just six counties are the locus of the overwhelming majority of the state's disposal of Class B material.

There are additional relationships that the matrix provides. Of the nearly 84,000 dry tons of Class B biosolids tracked by the matrix, roughly 73% of the total goes to Osceola County, 7% goes to Polk County, 4% goes to Brevard County, 4% goes to Gulf County and 3% goes to Charlotte County. The remaining 7% of biosolids transferred across county lines are distributed among the other 30 counties with active biosolids land application sites.

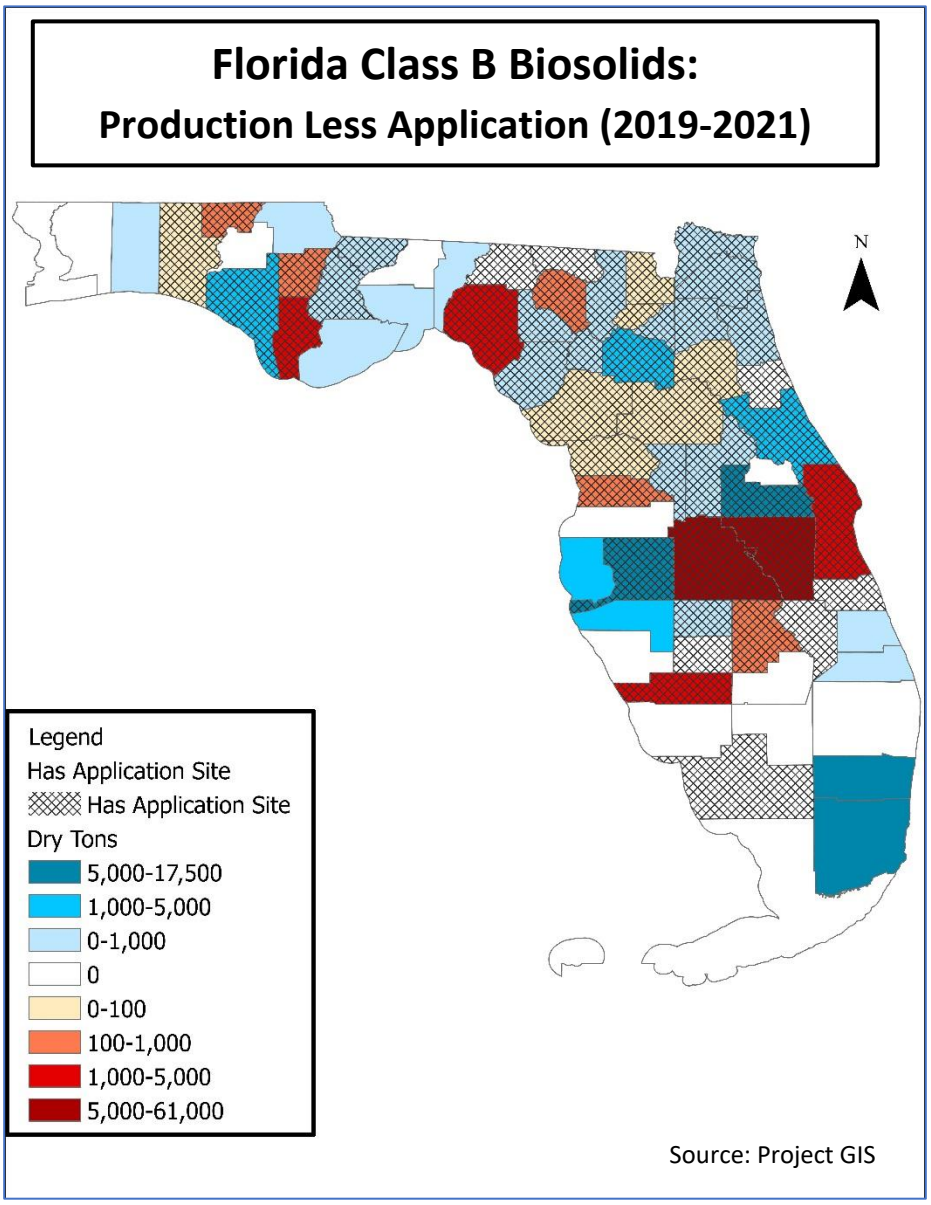
Several biosolids exporting counties are highly dependent on specific receiving counties. For example, Osceola County receives 96% of Brevard County's biosolids, 100% of Martin County's, 93% of Broward County's, 84% of Miami-Dade's and 80% of Volusia's. Taylor County receives 90% of Duval County's biosolids and 51% of the stream from Alachua County. In the Panhandle, Gulf County receives 100% of the biosolids from the following counties: Franklin, Jefferson, Wakulla plus 73% of Bay County's biosolids and 71% of Gadsden County's. Holmes County receives 84% of Okaloosa County's biosolids. The matrix also shows that many counties do not export Class B biosolids. Baker, Calhoun, Gulf, Hamilton, Madison, Okeechobee, Walton and Putnam counties all manage 100% of their own production.

Consistent with the provisions controlling the disposition of Class B biosolids within the Okeechobee Basin, Miami-Dade and Broward counties transfer significant volumes to Osceola and Polk counties. For Miami-Dade these transfers are approximately 195 miles and 205 miles, respectively; for Broward County the distances are 175 miles and 195 miles, respectively. Transfer distances for other major producers of Class B biosolids are generally less than 75 miles (except for Pinellas County for which Polk County is about 125 miles and Highlands County about 135 miles).

Another way to examine transfers of Class B biosolids is to calculate the net movements. The following graphic (**FIGURE 13**) denotes the differences between the average annual volumes of Class B biosolids produced at the county level and the volumes received.

Counties depicted in shades of blue are net exporters of Class B biosolids; counties depicted with shades of red are net importers. Nineteen of the 30 counties with a positive difference (i.e., where biosolids production is greater than receipts) have land application sites within their jurisdictions. Osceola, Polk, Brevard, Charlotte and Gulf counties stand out as net importers of Class B biosolids.

FIGURE 13. NET MOVEMENTS OF CLASS B BIOSOLIDS IN FLORIDA



It is emphasized that while Class AA production is tabulated and reported, Class AA distribution is highly problematic to determine. Private blenders may receive Class AA products from multiple sources, combine it with other compostable material and distribute packaged end products in-state and out-of-state through a variety of retailers and wholesalers.

- Our understanding of Class B management and distribution (including impacts) is increasing as the products share of all biosolids production declines.
- Net transfers of Class AA are unknown at the same level of detail as Class B.

Environmental Justice

Based on circumstances regarding land application of Class B biosolids elsewhere in the United States, environmental justice is a key consideration of this study, specifically, whether poor or marginalized communities are impacted negatively by transfers and application of Class B biosolids. While the Class B biosolids transfer matrix and the several maps describe the locations and magnitudes of material transfers, additional data must be assessed to evaluate the societal implications. In sum, the following statistical analysis explores the local impacts of exporting biosolids from counties with relatively high population densities (and limits to the areas suitable for land application) to those counties where land application has been permitted. The primary effect considered is socio-economic: are communities with active land application of Class B biosolids different in demographic and social makeup than those communities that export biosolids? The issues of whether marginalized populations may be exposed to any negative effects from the land application of biosolids (i.e., surface water impairment) or the landfilling of biosolids are addressed elsewhere in this report. The analysis was conducted at three levels: county-wide, the block group, and the sub-watershed and looked to evaluate differences between the characteristics of the generating counties and (1) receiving counties, (2) block groups with land application sites, and (3) block groups with land application sites that also include portions of watersheds impaired for nutrients.

An initial evaluation examined the relationship between the major South Florida counties that export Class B biosolids (Palm Beach County does not) and the two primary recipient counties: Osceola and Polk which receive about 84% of the state's Class B transfers. South Florida counties (Monroe, Miami-Dade, Broward and Martin) are urban relative to the receiving counties. The total population of the receiving counties is 1.1 million (2021) and the average population density is 353 persons per sq. mi. The total population of the exporting counties is greater than 5.0 million and the average population density is 1,083 persons per sq. mi, 3.6 times greater than that of the receiving counties. The median income (weighted by population) of the receiving counties is $56,298 (2021) while that of the exporting counties is $61,032 —8.4 percent greater.[1]

TABLE 8. DEMOGRAPHICS OF SELECT SENDING AND RECEIVING COUNTIES OF BIOSOLIDS IN FLORIDA

County Transfer Category	County	Median Household Income	Percent in Poverty	Percent Non-White	Percent Population <5	Percent Population >65
Exporting	Broward	$64,522	12.8%	67%	5.6%	17.2%
	Miami-Dade	$57,815	15.2%	86%	5.4%	15.8%
Receiving	Osceola	$58,513	13.3%	72%	6.0%	13.3%
	Polk	$55,099	15.6%	48%	5.6%	20.4%

Source: https://www.census.gov/quickfacts/fact/table/

TABLE 8 describes additional variables for the pairs of exporting and receiving counties. The data reflect 2021 US Census reports. For this table, the Percent Non-White was not determined by the "white alone" statistic (which was greater than 77% for the counties other than Broward, reported at 62%) but by

[1] In the Panhandle, the median income of Bay County (exporting) is 12.4 percent greater than that of Gulf County which receives 77% of Bay County's biosolids and 58.7 percent greater than that of Calhoun, which receives the remaining 23%.

calculating 100% of the population less the percent described as "white alone, not Hispanic or Latino).[2] For this table, the vulnerable age groups were selected as younger than 5 years and older than 65 years.[3]

The percentage of younger populations are slightly larger in the receiving counties, but the difference is not significant. The percentage elderly population of Osceola County is smaller than that of either Miami-Dade or Broward; Polk County reports a larger older population, but that county receives a smaller volume of biosolids.

In **TABLE 8** the (combined, young and elderly)) percent vulnerable populations range from a minimum of 21.2% of the county total population (Miami-Dade) to maximum of 26.0 for Polk County.[4] As Osceola County receives 26% and 22% of it biosolids from Broward and Miami-Dade, respectively, it cannot be argued that the less vulnerable population is impacting the more vulnerable population.

Median household income was negatively correlated with the percent in poverty. Given the high values for percent non-white in both Broward and Miami-Dade counties there was no apparent distributional impact based on race.

Socio-economics of Net Nutrient Transfer: A more comprehensive way to understand the movement of biosolids across counties is to calculate the net amount of biosolids imported by county. This measures the amount of biosolids that are entering a county minus the amount exported based on individual county characteristics. With this measure, all pure exporting counties will have a negative amount of net biosolids, but so will any county that exports more biosolids than they import.

Net Received Biosolids are calculated as Total Biosolids received from 2019 through 2021 minus all Biosolids exported from the county during that period. Thus, large positive values show large quantities of received biosolids to be disposed of via land application, while negative values reflect the export of biosolids from that county. This mechanism creates a numerical variable that is scaled by tons of biosolids rather than a simple categorical variable for counties that are pure importers or exporters of biosolids. The estimated regression is

$$NRB_i = \alpha + \beta_1 NW_i + \beta_2 MI_i + \beta_2 IP_i + \beta_2 SI_i + \beta_2 PTN_i + \beta_2 PTP_i + \varepsilon_i$$

Where *NRB* is Net Received Biosolids for each county *i*, *NW* is the percent of the population that is Non-White, *MI* is median income in the county, *IP* is the acreage of Improved Pasture in the county, *SI* is the number of septic installations in the county (see Table 10), *PTN* is the Total Nitrogen in the county expressed as a percent of the total quantity of nitrogen transferred) and *PTP* is Total Phosphorus also expressed similarly as a percent. This regression tests the relationship between each explanatory variable and the amount of biosolids received in that county. A positive effect indicates a positive correlation. This regression model explains 27% percent of the variation in the net receiving figures.

In Table 3Table 9, this model shows that median income in a county is positively correlated with the amount of biosolids it receives. Each additional dollar of income increases the net amount of biosolids received by 0.73 dry tons. This effect is statistically significant with a 90% Confidence Level (CI). Improved

[2] For the broader statistical assessments of this study the Percent Non-White variable is used as provided by the Census with no further breakdowns of race or ethnicity.
[3] For the broader statistical assessments of this study the vulnerable age groups were <5 years and >60 years.
[4] The combined percent vulnerable population for Polk County is smaller than that for either Broward or Miami-Dade.

Pasture is also associated with more biosolids: each additional acre of improved pasture is associated with an increase of 0.24 tons of biosolids (significant at the 99% CI.) The percent of Total Nitrogen is positively correlated with receiving biosolids, while the percent of Total Phosphorous is negatively correlated, both significant at the 95% CI. The implication is that counties relatively high in TP export more biosolids to counties that have relatively elevated levels of TN. The level of multi-collinearity in this regression is within acceptable levels, as measured by the variance inflation factor (VIF) scores, suggesting that the correlations among explanatory factors are at a manageable level overall. The White test shows no significant heteroskedasticity.

TABLE 9. MEASURES OF TOTAL NITROGEN AND TOTAL PHOSPHOROUS BY COUNTY BY SENDING STATUS

VARIABLES	(1) PCT_TN_County	(2) PCT_TP_County	(3) TN
Send Only	3.629	7.852	0.0724
	(3.721)	(5.506)	(0.115)
Receive Only	5.835	10.03	0.163
	(4.507)	(6.668)	(0.139)
Constant	9.521***	9.065***	0.837***
	(1.593)	(2.358)	(0.0492)
Observations	67	67	67
R-squared	0.035	0.055	0.024

Notes: Standard errors are in parentheses; significant variation from the control is shown by asterisks: *** p<0.01, ** p<0.05, * p<0.1

Septic systems are negatively correlated with received biosolids (positively associated with exporting counties), but it is significant at the 88% CI which is outside of our accepted bounds.

TABLE 10. COUNTY AREA AND NUMBER OF SEPTIC INSTALLATIONS MEAN DIFFERENCE FROM COUNTIES THAT SEND AND RECEIVE BIOSOLIDS BY SENDING STATUS

VARIABLES	(1) County Area	(2) OSTDS (Septic) Installations
Send Only	33,349	6,598
	(154,903)	(13,949)
Receive Only	13,634	-17,484
	(187,597)	(16,893)
Constant	675,164***	42,047***
	(66,326)	(5,972)
Observations	67	67
R-squared	0.001	0.023

Notes: Standard errors are in parentheses; significant variation from the control is shown by asterisks: *** p<0.01, ** p<0.05, * p<0.1

Biosolids and Surface Waters

Analysis of the relationship between land application of biosolids and waters of the state was addressed at the USGS Hydrologic Unit Code 12 (HUC12) level. The hydrologic unit codes describe the location of the watershed and the "level" of the unit, for which there are six increasingly defined levels of detail. The lower-level polygons (i.e., HUC2 and HUC4) cover larger geographies than higher level ones. Higher levels (e.g., HUC10 and HUC12) are thus nested within the successive lower levels. The analysis conducted occurred at the smallest size watershed for which USGS nation-wide data exist.

The HUC12 watershed analysis was conducted to obtain a more refined view of Class B biosolid land applications. Across the state of Florida, there are 1,378 HUC12 watersheds totaling 65,705 square miles. Distributed across central and northern Florida there are 155 HUC12 watersheds that have application sites. 107 of these sites were active during 2019-2021. The total area of the applied HUC12 watersheds is 7,086 square miles, about 11% of Florida's HUC12 watershed area. Furthermore, the average applied HUC12 watershed area is 45.71 square miles (min –9.6, max – 246), and the average application site area is 1.02 square miles (min – 0.0041, max – 52). Many application sites will take up a portion of a HUC12 watershed but there are a few large ones spanning across multiple HUC12 watersheds.

As mentioned above, counties that have land applied a total of over 5,000 dry tons of Class B biosolids from 2019 to 2021 (three years) include Osceola (194,148), Polk (18,569), Brevard (15,983), Gulf (8,972), and Charlotte (7,771). The HUC12 watersheds applied in these counties occupy only a portion of each county's area and, in some instances, extend across multiple counties. Out of 155 HUC12 watersheds that have a Class B application site, there are 19 that have applied over 5,000 dry tons. These are in Osceola, Orange, Brevard, Indian River, Gulf, Calhoun, and Charlotte counties. There are 15 HUC12 watersheds that have applied between 1,000 and 5,000 dry tons of Class B biosolids. These are in Taylor, Dixie, Lafayette, Polk, Calhoun, Highlands, Hardee, DeSoto, Hernando, and Suwannee counties. Finally, all counties just mentioned, excluding Polk, Orange, Charlotte, Gulf, and Calhoun, are applying less than 1,000 dry tons throughout HUC12 watersheds in their jurisdiction. There are 136 such HUC12 watersheds applying this amount.

Looking at all 1,378 HUC12 watersheds across Florida, about 57% (50.2% plus 6.5%) are impaired by nitrogen or phosphorus, TN or TP. Approximately 7% of Florida HUC12 watersheds are impaired by TN or TP and also have a Class B land application site. When looking only at the watersheds with application sites, about 58% (90 of a total of 155) of HUC12 watersheds are impaired. The results of the logistic regression ($p = 0.7253$) indicate no statistically significant relationship between biosolids Class B application site presence and TN or TP presence across the state of Florida.

Unimpaired Watersheds – No Biosolids

- 531/1,378 (38.5%)

Unimpaired Watersheds – Biosolids

- 65/1,378 (4.7%)

Impaired Watersheds – No Biosolids

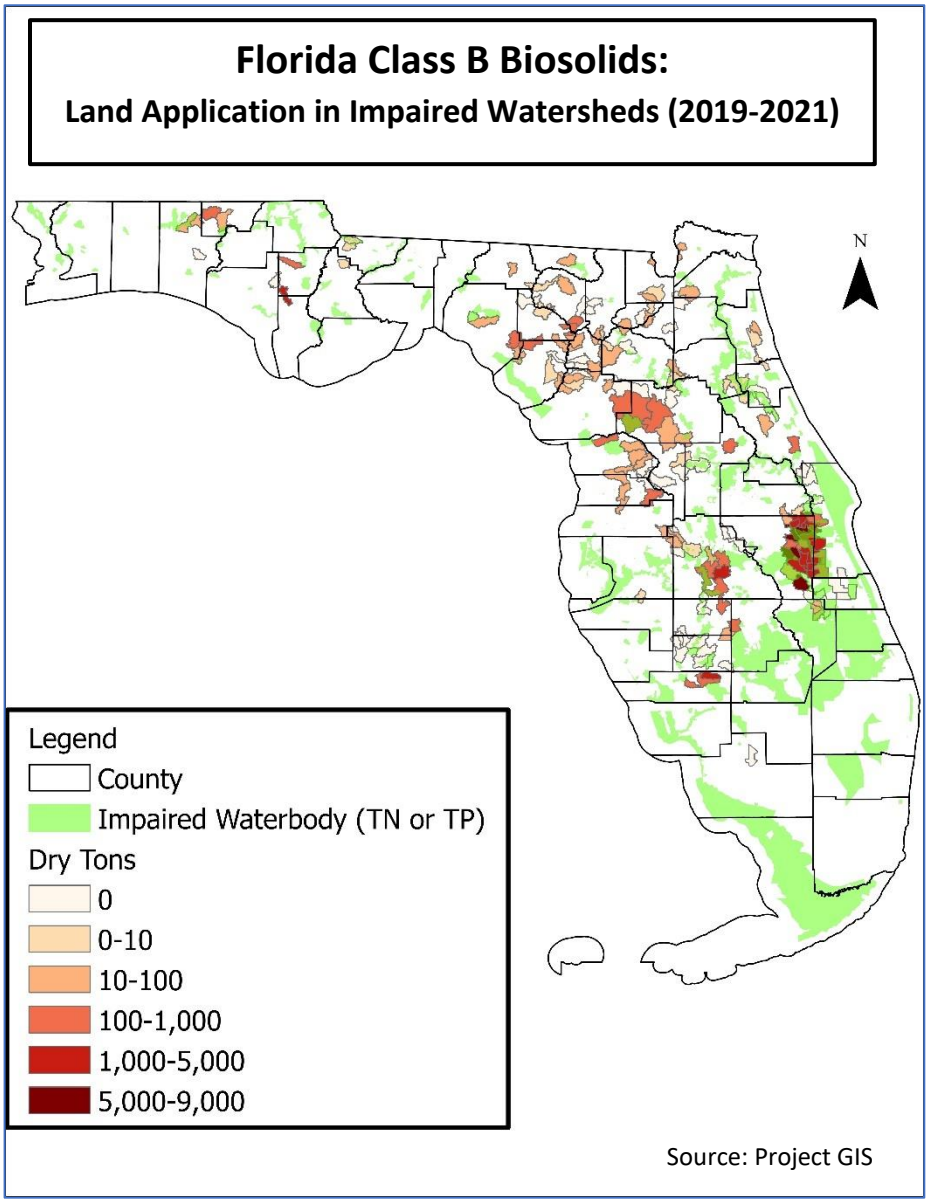
- 692/1,378 (50.2%)

Impaired Watersheds – Biosolids

- 90/1,378 (6.5%)

Adding watershed characteristics and land cover data shows that other factors have a greater influence on TN or TP presence at the HUC12 level across the state of Florida. Slope, Depth to Water Table (WTD), Flooding frequency (Dominant and Maximum), Improved Pasture (IP), and the percentage of High Intensity Urban (HIU) are statistically significant variables in the logit model. The results indicate that the odds of TN or TP presence increase as Flooding Frequency (dominant), IP, and HIU increase. The odds of TN or TP presence decrease as Slope, WTD, and Flooding Frequency (Maximum) increase.

FIGURE 14. ANNUAL APPLICATION OF CLASS B BIOSOLIDS NEAR IMPAIRED WATERBODIES



Surface Water Quality and Class B Biosolids Land Application Sites:
HUC12 watershed area across the state of Florida ranges from 0 to approximately 63.85 square miles. The average application site area across Florida is approximately 0.88 square miles. The results of the logistic regression indicate a significant relationship between Florida HUC12 Class B application site area and TN or TP presence. The results show the odds of TN or TP-impaired waterbody presence increase by about 1.05% for every square mile increase in the application site area. Adding watershed characteristics and land cover area to the analysis, the results indicate no significant relationship between application site area and TN or TP presence across the state of Florida.

Looking only at HUC12 watersheds with an application site, the average area of the Class B application site increases to approximately 7.84 square miles. At this scale, the application site area also shows a significant relationship with TN or TP presence. The odds of having a TN or TP-impaired waterbody in a HUC12 watershed with an application site increase by 1.06% with every square mile increase. Application site area shows no significant relationship, however, when adding watershed and land cover characteristics at this scale either.

Surface Water Quality and Class B Biosolids Land Application Quantity:
Florida HUC12 watershed annual Class B application quantities across 2019 to 2021 ranged from 0 to 148,929 dry tons. The average quantity applied across all Florida HUC12 watersheds is 1,852 dry tons for 2019 to 2021 combined. The results show the odds of TN or TP-impaired waterbody presence increase by ~1% for every dry ton increase in the application site quantity applied. While Florida HUC12 watershed annual Class B application site quantities show a significant relationship with TN or TP presence, no significant relationship is observed when considering watershed and land cover characteristics across the state of Florida.

The average quantity applied across HUC12 watersheds in Florida with a Class B application also increases to 16,463 dry tons for 2019 to 2021 combined. When looking only at HUC12 Watersheds with an application site and watershed and land cover characteristics, the logit model shows no significant relationship between Class B application site quantities and TN or TP presence either. At this scale, the results suggest similar patterns to application site presence and area in terms of watershed and land cover characteristics.

Watershed and Land Cover Characteristics influencing TN or TP presence across HUC12 Watersheds with a Class B application site include Slope, Improved Pasture (IP), and percent in Low Intensity Urban (LIU). The results indicate that the odds of TN or TP presence increase as Slope and IP increase. The odds of TN or TP presence decrease as LIU increases.

Conclusions Regarding Class B Application Sites and Surface Water Quality
Altogether, the results show that the presence of an application site does not influence TN or TP presence when other variables are included; impacts are observed however at application volumes greater than 5,000 dry tons. This may be due to the widespread occurrences of TN or TP impaired waterbodies across the state and minimal variation in application site presence.

While the results do indicate similar significant relationships between HUC12 application site area, Class B quantities, and TN or TP presence across the state (and only in HUC12 watersheds with an application site), watershed characteristics and land cover characteristics seem to outweigh the influence of Class B application sites. At the state level, these characteristics include Slope, WTD, Flooding Frequency

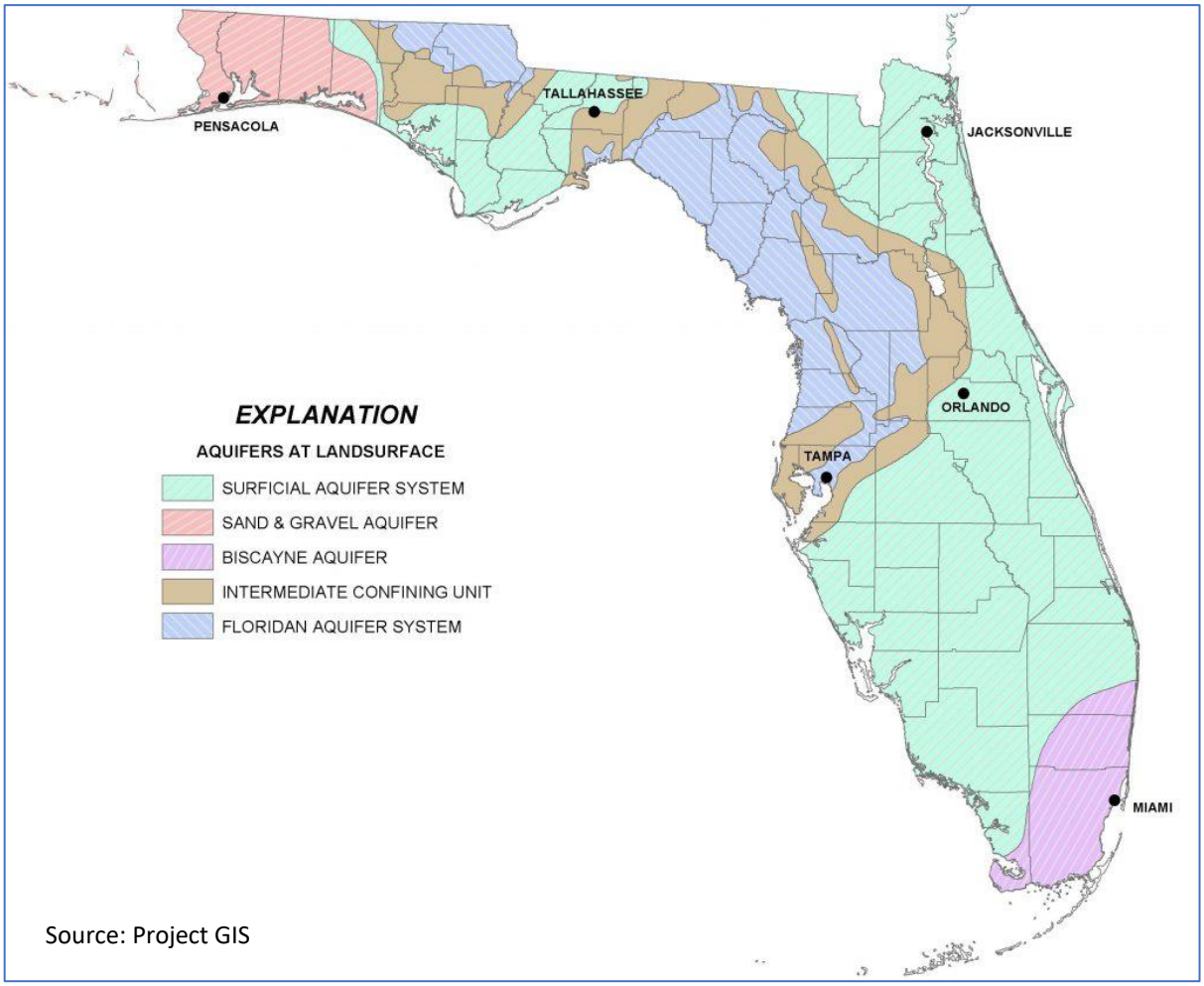
(Dominant and Max), IP, and HIU. Isolating only the HUC12 watersheds with Class B application sites, the characteristics include Slope, IP, and LIU. It is important to note that TN or TP presence decreases at the state level with increasing slope but increases with increasing slope when only looking at watersheds with Class B application sites.

- At the statewide level, TN or TP decreases in HUC12 watersheds with increasing slope since Florida is relatively flat (1.98) but there is considerable variation (0 - 13.3). Larger slopes should contribute to dilution due to higher flows of water. HUC12 watersheds with Class B application sites are more than twice as flat (0.65 - 7.64) so any increase in slope in these locations may not be large enough to generate enough flow for dilution to take place.
- At the statewide level, TN or TP decreases with increasing depth to water table due to the contribution groundwater plays in influencing the transport of pollutants to surface water bodies. Greater depth makes it harder for pollutants to reach these systems (0cm - 118.60cm, Avg. - 29.67).
- At the statewide level, TN or TP increases with increasing Flooding Frequency (Dominant) since Florida is relatively flat and polluted water will stay within small watersheds and nearby waterbodies during dominant flooding (0 - 5.02, Avg. - 1.25). TN or TP decreases with increasing Flooding Frequency (Maximum) since Florida is relatively flat and water may move across and far from watersheds during larger floods (0 - 5.02, Avg. - 1.28). It is important to note differences in Flooding Frequency between the state level analysis and the application watershed analysis (0.89 - 1.87, Avg. - 1.11). These numbers show rare flooding in HUC12 watersheds where Class B land applications are occurring.
- At the statewide level, TN or TP increases with increasing Improved Pasture (IP), which uses fertilizer as well as biosolids, results in land use change and runoff, and there is considerable variation across Florida HUC12 watersheds (0 - 128.63, Avg. - 6.81). Looking at HUC12 watersheds with Class B application sites, the average area covered by IP increases almost three times as much as the state (0 - 107.97, Avg. 16.51).
- At the state level, TN or TP increases with increasing percentages of High Intensity Urban since HIU contributes to runoff, and there is considerable variation across Florida HUC12 watersheds (0 - 58.01, Avg. - 2.94). There is less variation in HIU levels when looking only at applied HUC12 watershed (0, 32.88, 1.99)
- Isolating HUC12 watersheds with Class B application sites shows TN or TP decreases as the percentage of Low Intensity Urban increases due to still significant levels of urban development and population density. While there is slightly more IP at the applied HUC12 watershed scale (0 - 30.42, Avg. - 2.44) there is considerable variation across the state (0 - 30.42, Avg. 1.66).

Biosolids and Groundwater

Florida's hydrogeology is dominated by the Floridan Aquifer (largely confined but for outcroppings in the north-central peninsula and Marianna Highlands — Jackson County) and a complex of surficial systems more readily affected by land use (Figure 15). "Intermediate confining units" are partially confined and generally exhibit less susceptibility to pollution, etc., than other surficial systems.

FIGURE 15. SURFICIAL AQUIFERS IN FLORIDA



Source: Project GIS

To examine potential impacts of land applied Class B biosolids on groundwater, wells within the state's monitoring network were categorized by the type of aquifer sampled. State groundwater monitoring wells are not located within permitted Class B application sites themselves. Consequently, the surface watershed containing the well was used as the spatial context for groundwater quality in the vicinity of the well, which may or may not be affected by Class B biosolids applications.

Out of Florida's 1,378 HUC12 watersheds, there are 433 watersheds with groundwater monitoring sites where data are available for TN and TP between the years 2019 to 2021. There are 247 HUC12 watersheds where data are available for unconfined (surficial) aquifers and 252 watersheds where data are available for confined aquifers.

FIGURE 16. HUC12 WATERSHEDS WITH GROUNDWATER MONITORING WELLS

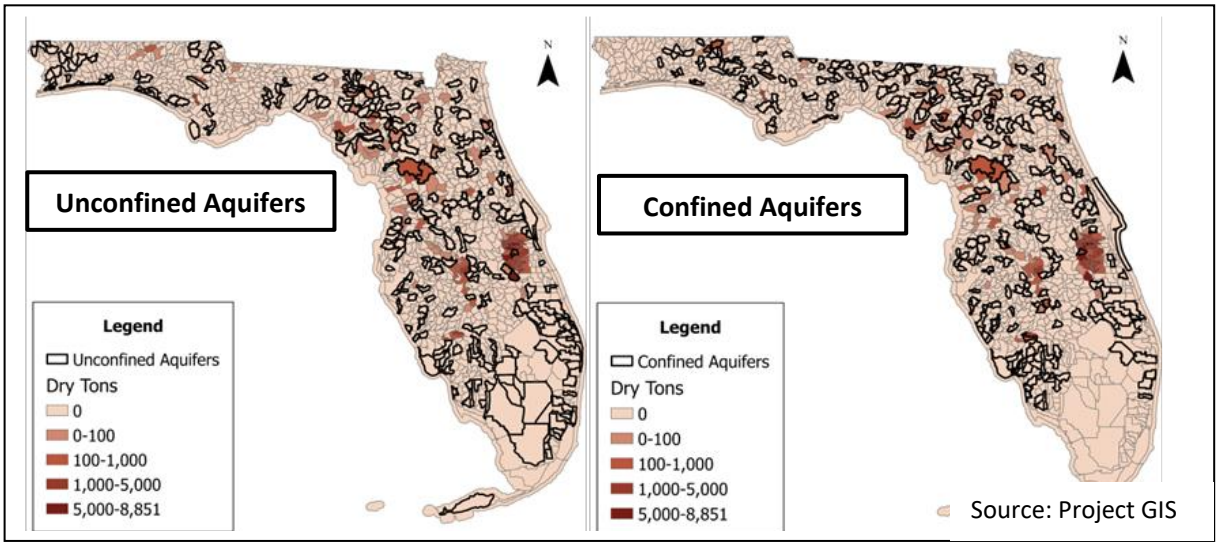
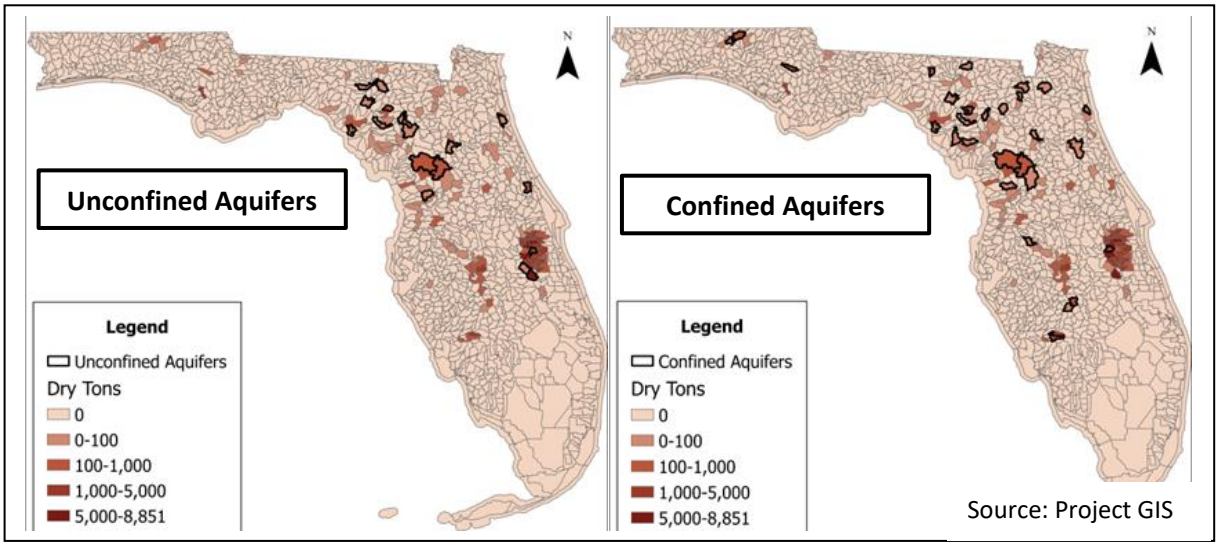


FIGURE 16 presents the HUC watersheds with groundwater wells that provide nutrient data from both unconfined and confined aquifers. There are 107 HUC12 watersheds that have been applied with Class B biosolids and 40 of these have nutrient data available. Of these, 18 have data available for unconfined aquifers and 28 have data available for confined aquifers. The figure also depicts areas with Class B application sites. FIGURE 17 highlights just those watersheds associated with Class B application sites.

FIGURE 17. CLASS B APPLICATION WATERSHEDS WITH GROUNDWATER DATA



Statewide Groundwater Nutrient Data

Analysis was undertaken to examine whether (surface) watersheds applied with Class B biosolids have an influence on nutrient levels in underlying aquifers, and if there is a significant difference between the influence in unconfined aquifers and confined aquifers. Unconfined aquifers are directly affected by local recharge and therefore more vulnerable to contamination than confined aquifers that are capped with less permeable layers of rock or clay. Concentrations of TN and TP in groundwater in unconfined

(UC) and confined (CA) aquifers were compared between watersheds applied with Class B biosolids and watersheds that have not been applied with biosolids.

TABLE 11 reports that groundwater TP and TN concentrations in confined aquifers are greater in watersheds that have applied Class B biosolids compared to groundwater within HUC watersheds that have not applied Class B biosolids. Groundwater TP is about twice as much while TN values are almost six times as high. Within unconfined aquifers, groundwater nutrient concentrations are higher in watersheds that have not applied Class B biosolids, but the differences are not statistically significantly.

Average nutrient levels statewide are about twice as high in unconfined aquifers compared to confined aquifers (0.16 mg/l versus 0.07 mg/l for TP and 0.64 mg/l versus 0.34 mg/l for TN).[5] On average, TN concentrations are about four to five times larger than TP in groundwater sites.

TABLE 11. NUTRIENT CONCENTRATIONS IN FLORIDA AQUIFERS, BY HUC12 BOUNDARIES

	Unconfined	Confined
TP	0.157	0.071
Applied	0.129	0.137
Not Applied	0.160	0.063
TN	0.644	0.343
Applied	0.401	1.287
Not Applied	0.663	0.225

Source: DEP groundwater well monitoring data

Watersheds that have not been applied with biosolids show similar patterns and averages to those observed at the statewide level. Concentrations of both TP and TN in unconfined aquifers are higher than in confined aquifers.

Within watersheds that have been applied with Class B biosolids, TP concentrations range from 0.014 mg/l to 0.67 mg/l in unconfined aquifers (and average 0.13 mg/l) and from 0.003 mg/l to 1.8 mg/l in confined aquifers (and average 0.14 mg/l). TN concentrations range from 0.004 mg/l to 1.3 mg/l in unconfined aquifers (average of 0.40 mg/l) and from 0.004 to 15 mg/l in confined aquifers (average of 1.29 mg/l).

Groundwater TP concentrations in confined and unconfined aquifers are not statistically different in watersheds with Class B applications; in watersheds without Class B applications, TP concentrations are significantly higher in unconfined aquifers. In watersheds with Class B applications, groundwater TN concentrations in confined aquifers are significantly greater than in unconfined aquifers; conversely, in watersheds without Class B applications, TN concentrations are greater in unconfined aquifers.

[5] TP concentrations range from 0.002 to 2.90 mg/l in unconfined aquifers statewide and from 0.002 mg/l to 2.0 mg/l in confined aquifers. TN concentrations range from 0.004 to about 16.0 mg/l in both unconfined and confined aquifers. The range of TN concentrations in confined aquifers is greater in watersheds with application of Class B biosolids than in those that have not applied biosolids. The range of both TP and TN concentrations in unconfined aquifers is greater in watersheds that have not applied biosolids than in applied watersheds. The range of TP values for confined aquifers in applied watersheds is less than watersheds that have not applied biosolids, but the average is higher in applied watersheds, which is the result if there are many non-applied watersheds with low measurements.

Groundwater sites are broadly distributed throughout the state and are influenced by a wide range of environmental variables: comparing nutrient levels between applied and non-applied watersheds alone is insufficient to address the influence of Class B biosolids applications on groundwater quality.

A more targeted approach that compares watersheds with Class B applications to non-applied watersheds that are in close proximity (and therefore more similar to applied watersheds) may highlight the influence of applied biosolids on groundwater quality while controlling for regional environmental differences. For this subsequent analysis, non-applied watersheds (with groundwater data) that intersect (adjoin or abut) the Class B applied watersheds (with groundwater data) were selected for comparison. FIGURE 18 shows the non-applied watersheds that intersect watersheds with land application of Class B biosolids. For unconfined aquifers there are 18 applied watersheds and 19 adjoining watersheds with groundwater data. For confined aquifers there are 28 applied watersheds and 16 adjoining watersheds with groundwater data.

FIGURE 18. GROUNDWATER: HUC12 WATERSHEDS ADJOINING THOSE WITH LAND APPLICATION AND DATA

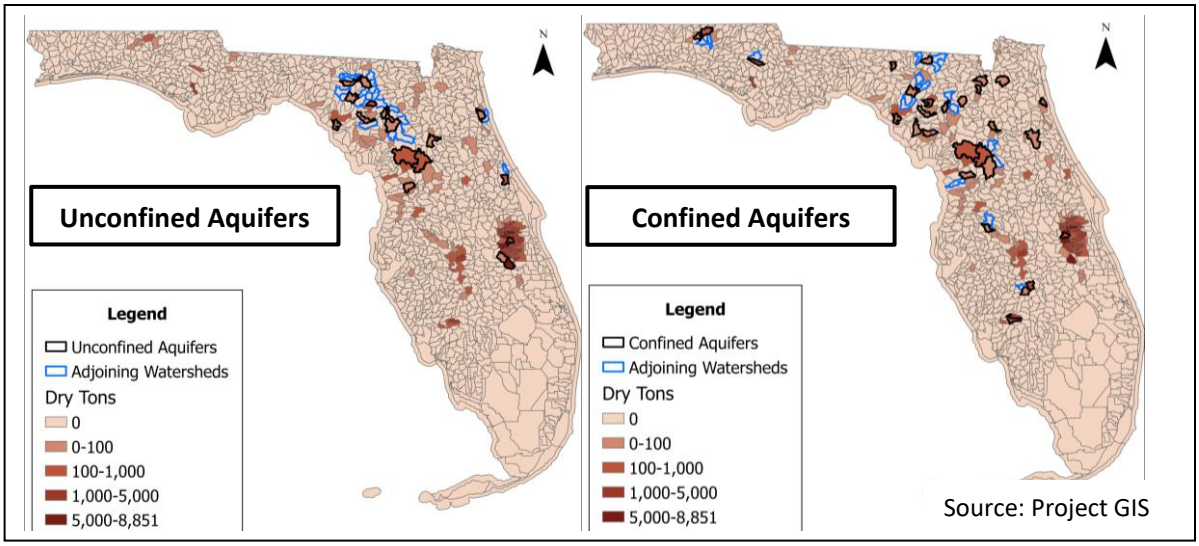


TABLE 12 shows the average groundwater nutrient concentrations in HUC12 watersheds applied with biosolids and HUC12 watersheds adjoining these applied watersheds (with groundwater data). Compared to the broader watershed analysis above, this analysis shows a large increase in TN concentrations for unconfined aquifers in adjoining watersheds not applied with biosolids (2.70 mg/l vs. 0.66 mg/l). Both TP and TN concentrations, however, are still higher in the confined aquifers of watersheds that have been applied with biosolids. This analysis also shows that there are greater concentrations of TP and TN in the unconfined aquifers of non-applied watersheds.[6]

[6] Nutrient concentrations remain greater for confined aquifers compared to unconfined aquifers in watersheds applied for biosolids, and concentrations for confined aquifers remain greater in applied watersheds compared to adjoining watersheds that have not been applied: TP range: 0.003 mg/l to 0.4 mg/l, average of 0.06 mg/l; TN range: 0.004 mg/l to 1.75 mg/l, Average: 0.18 mg/l. Nutrient concentrations for unconfined aquifers remain lower in applied watersheds compared to non-applied watersheds: TP range: 0.01 mg/l to 0.77 mg/l, average of 0.14 mg/l); TN range: 0.004 mg/l to 16.5 mg/l, average of 2.7 mg/l; however, TN is greater in adjoining non-applied watersheds.

TABLE 12. NUTRIENT CONCENTRATIONS IN FLORIDA AQUIFERS, BY HUC12 BOUNDARY, INCLUDING ADJOINING WATERSHEDS

	Unconfined	Confined
TP	0.133	0.109
Applied	0.129	0.137
Not Applied	0.137	0.060
TN	1.584	0.886
Applied	0.401	1.287
Not Applied	2.704	0.184

Source: DEP groundwater well monitoring data

Expanding the analysis to include non-applied watersheds with groundwater data that adjoin all applied watersheds (with or without groundwater data) provides a better understanding of groundwater near application sites in general. FIGURE 19 shows the non-applied watersheds that intersect all applied watersheds. For unconfined aquifers there are 18 applied watersheds and 52 adjoining watersheds. For confined aquifers, there are 28 applied watersheds and 46 adjoining watersheds with groundwater data.

FIGURE 19. GROUNDWATER: HUC12 WATERSHEDS ADJOINING WATERSHEDS WITH LAND APPLICATION WITH OR WITHOUT DATA

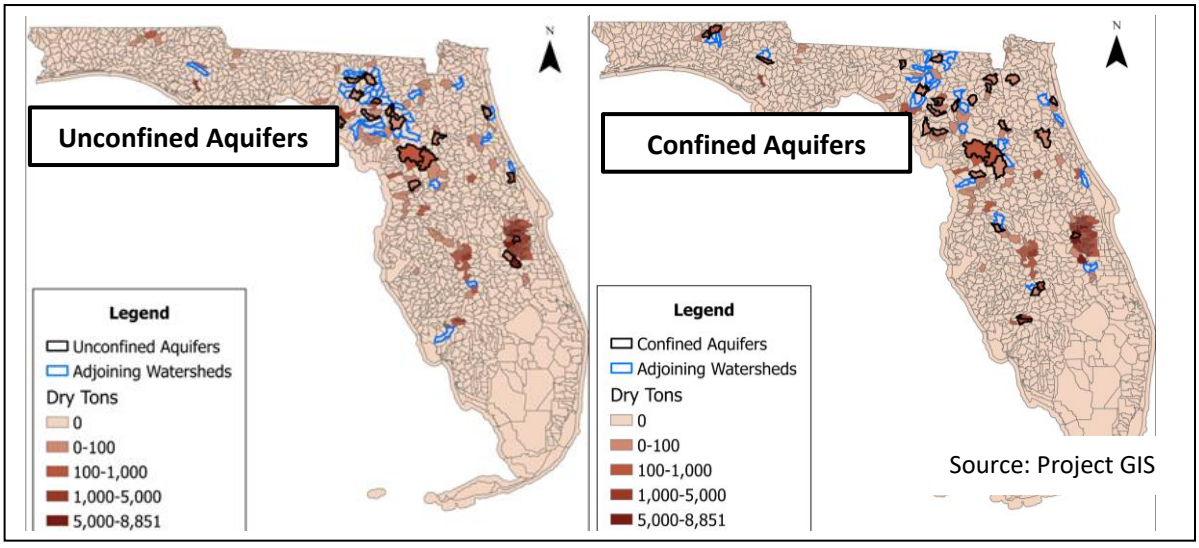


TABLE 13 shows the average nutrient levels for TN and TP in HUC12 watersheds adjoining watersheds with land application of Class B biosolids, whether the latter have groundwater data or not. Compared to the previous analysis, there is a decrease in TN for unconfined aquifers and an increase in TN for confined aquifers in adjoining HUC12 watersheds not applied with biosolids. However, nutrient levels are still higher for confined aquifers compared to unconfined aquifers in watersheds applied for biosolids, and nutrient levels for confined aquifers are still higher in applied watersheds compared to adjoining watersheds. Nutrient levels in unconfined aquifers for TP, on the other hand, are slightly higher in applied watersheds.

TABLE 13. NUTRIENT CONCENTRATIONS IN FLORIDA AQUIFERS, BY HUC12 BOUNDARY INCLUDING ADJOINING WATERSHEDS, WITH OR WITHOUT DATA

	Unconfined	Confined
TP	0.121	0.094
Applied	0.129	0.137
Not Applied	0.118	0.068
TN	1.210	0.776
Applied	0.401	1.287
Not Applied	1.491	0.464

Source: DEP groundwater well monitoring data

Overall, phosphorus concentrations in unconfined aquifers are not significantly different between applied and non-applied watersheds while nitrogen concentrations are greater in the non-applied watersheds. Conversely, in confined aquifers, both phosphorus and nitrogen concentrations are greater in watersheds with land application of Class B biosolids.

Land Cover

Land cover geohydrologically upgradient may contribute to nutrient concentrations in the adjoining, downgradient monitored aquifer, particularly with regards to nitrogen as suggested by TABLE 13. Similar to the assessment of the relationships between land cover and nutrient concentrations in surface waters, land cover was correlated with groundwater nutrient concentrations, for both the overlying HUC watershed and the adjoining HUC watershed. Appendix E includes the statistical output for the analysis.

The results show that Tree Plantations (14% coverage over unconfined aquifers—UA, and 19% coverage over confined aquifers —CA) are the dominant land cover types in both applied watersheds and watersheds that adjoin all applied watersheds followed by Improved Pasture (13% UA, 12% CA). Looking only at applied watersheds, Tree Plantations (16% UA, 17% CA) and Improved Pasture (16% UA, 13% CA) remain the dominant land cover types. Adjoining watersheds not applied with biosolids also have Tree Plantations (13% UA, 20% CA) and Improved Pasture (12% UA, 12% CA) as the dominant land cover type.

In sum, the effects of land cover in adjoining HUC12 watersheds on the unconfined aquifer may be difficult to sever from those otherwise attributable to land application of Class B biosolids.

Conclusions Regarding Class B Application Sites and Ground Water Quality

- Nutrient levels are higher in confined aquifers compared to unconfined aquifers.
- Nutrient levels for confined aquifers in applied watersheds are 2 - 6 X higher compared to the state and watersheds that have not been applied with biosolids.
- Nutrient levels for unconfined aquifers in applied watersheds are slightly less than those observed at the state level and in watersheds that have not been applied with biosolids.

Contaminants of Emerging Concern

Biosolids have been regulated historically by the EPA (and by extension, the State of Florida) only for metals, including Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, and Zinc.[7] In 2003, EPA made a determination not to regulate dioxins and dioxin-like compounds in land-applied

[7] Table 1 of 40 CFR § 503.13.

sewage sludge. However, biosolids have been identified as containing contaminants of emerging concern (CECs).

> "Contaminants of emerging concern include a wide range of chemical compounds used in common household and personal care products such as lotions, soaps, insect repellents, and sunscreens. They are of emerging concern because of associated risks they present to human health and the environment. Many chemicals defined as CECs are known or suspected toxins, and some are endocrine disruptors, meaning they interfere with the normal functioning of hormones in the body. CECs may also be linked to biological abnormalities and mutations in aquatic life."[8]

PFAS: Predominant among CECs in recent news and regulatory activity are PFAS (Per- and polyfluoroalkyl substances) and associated chemicals such as perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). While PFAS have received significant attention, the EPA reviewed 2018-2019 data and found many other classes of contaminants in biosolids including dioxins and furans, PCBs, flame retardants, volatile hydrocarbons, pharmaceutical drugs, polycyclic aromatic hydrocarbons (PAHs), pesticides, antimicrobial ingredients (parabens), heavy metals, and fragrance additives.[9]

PFAS are a group of chemicals employed in fluoropolymer coatings and products that resist heat, oil, stains, grease, and water. These coatings are applied to products such as clothing, furniture, adhesives, food packaging, heat-resistant non-stick cooking surfaces, and the insulation of electrical wire. PFAS have become a concern because they (1) do not break down readily in the environment, (2) can migrate through soils and thereby contaminate drinking water sources, (3) have been shown to bioaccumulate in wildlife, and (4) have been detected in surface waterbodies.

PFAS enter the wastewater treatment train via industrial, commercial, and domestic sources. Households are a significant source of PFAS derived from consumer products, and wastewater facilities with higher wastewater volumes from industry do not necessarily have higher PFAS loads. Conventional primary, secondary, and even tertiary treatment (i.e., nutrient reduction) do not materially reduce PFAS concentrations. As septage is (partially) dried, PFAS concentrations increase and as a result whether biosolids are land applied, landfilled, or incinerated, there are varying risks of contamination: each approach to biosolids management has its unique pathways of exposure. Specifically, land application of biosolids introduces PFAS directly into the environment.[10]

Further, land application of Class B biosolids to farmland is not the only land-based pathway for PFAS. Various brands of fertilizers for domestic use (i.e., those distributed through retailers) are derived in part from biosolids.[11] Labels for these products often include phrases such "eco," "natural," or "organic."

[8] https://www.i4es.org/emerging-contaminants/#:~:text=What%20are%20CECs%3F,%2C%20insect%20repellents%2C%20and%20sunscreens.
[9] United States Environmental Protection Agency. 2021. Biennial Review of 40 CFR Part 503 as Required under the Clean Water Act Section 405(d)(2)(C). Biosolids Biennial Report No. 8 (Reporting Period 2018–2019). EPA-822R21001.
[10] Research by Pepper et al. (2021) and Vedegari et al. (2018) suggests that PFAS levels in biosolids-amended soils are not statistically greater than those without a history of biosolids application, but these results depend on the source material and use of irrigation.
[11] Milorganite was introduced as the first pelletized fertilizer in the United States in 1926.

While biosolids are not allowed to be applied on farms growing certified organic fruits, vegetables, or dairy products[12] PFAS concentrations in these commercial fertilizers are not regulated. In one study, eight of nine products exceeded the screening limits for PFOS or PFOA set by Maine, a state with robust regulations action on PFAS in biosolids.

While the EPA had established guidelines for PFAS in drinking water, and rulemaking is underway for new PFAS drinking water limits,[13] there has been no federal effort to regulate PFAS in biosolids.[14] However, to address potential public health risks, several states have undertaken efforts to mitigate the presence of PFAS in biosolids and the landscapes affected by disposal.

Maine is the only state with a ban on the land application of biosolids (although land application of septage remains permittable), and only four states are currently proposing legislation for managing PFAS in biosolids.[15] Per a survey, New Hampshire is the only state requiring facilities to monitor PFAS in biosolids.[16] Massachusetts and Michigan do not have legislation on monitoring but have related requirements. Since 2019 Massachusetts has required that residuals approved for land application monitor for PFAS on a quarterly basis. Since 2021 Michigan has required monitoring of PFAS in biosolids for all land-applied biosolids and since 2017 has prohibited application of biosolids deemed to be industrially impacted.

For many states the allowable uses for land applied biosolids depend on the class of biosolids being applied. For example, some state-specific processes include compost feedstocks (Virginia, Washington), fiber crops (South Carolina, Washington), turf farms (South Carolina, Virginia), tree farms (Massachusetts, Minnesota), landfill daily cover (New Jersey, Virginia), and mine reclamation (Alabama, Minnesota, Virginia). Nine states are considering other types of regulatory actions and numerous state may propose new laws pending the outcomes of EPA's biosolids risk assessment study (i.e., new regulations, establishing a national standard, or publishing recommendations or guidelines). It should be added that nine states (Arizona, Colorado, Massachusetts, Michigan, Minnesota, New Hampshire, North Carolina, Tennessee, and Texas) local jurisdictions that have adopted their own standards, bans, monitoring regimes, or other regulations related to biosolids disposal or land application.[17]

[12] United States Food and Drug Administration. 2013. National Organic Program: Allowed & Prohibited Substances. https://www.ams.usda.gov/sites/default/files/media/Allowed-Prohibited%20Substances.pdf

[13] On March 14, 2023, EPA announced the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals), perfluorohexane sulfonic acid (PFHxS), and perfluorobutane sulfonic acid (PFBS). The proposed PFAS NPDWR does not require any actions until it is finalized, expected in late 2023.

[14] The EPA is funding research to develop a plan to address PFAS in wastewater. https://insideclimatenews.org/news/30102023/epa-to-fund-studies-of-toxic-forever-chemicals-in-agriculture/

[15] Maines is considering revising its ban.

[16] Environmental Council of States, 2018.

[17] As an example, the town of Thurston (Steuben County, PA) banned the use of biosolids as fertilizer on October 18, 2023, specifically because of concerns about PFAS in groundwater.

In sum, the regulation of PFAS in biosolids, whether at the source facility or at application sites, is a growing phenomenon nationally.[18,19] The issue is heightened where PFAS — potentially from biosolids —is detected in drinking water, which itself is the subject of tighter standards for PFAS. Should the EPA enact standards where contaminant levels are less than what is typically found in Florida's land-applied biosolids, the treatments and means of disposal may shift significantly.

Alternative Treatments

Alternative technologies may present technically and cost-feasible paths to the disposal of biosolids that reduce the environmental impacts associated with land application and landfilling. As noted above, such alternatives include extended composting (beyond the specifications of Class AA), thermal processing, supercritical water oxidation, anaerobic digestion, and other WTE facilities (including cement production). There are documented efforts elsewhere in the United States to scale these latter technologies, but for purposes of this study they are effectively pilots or bench-level approaches and not included in the cost-benefit assessment.

Composting: Composting is an established technology in Florida with firms like Harvest Quest, Compost USA, and Covanta (now Reworld), among others.[20] The production of Class AA (or better) materials allows for unregulated distribution to agricultural, horticultural, and domestic use. Common practice includes the blending of dewatered biosolids with carbon-rich bulking agents such as yard waste, wood chips and oversized particles of compost from prior operations. Woody yard debris is broadly available from municipal collection and from tree service companies. Extensive mixing of biosolids with the bulking agents is necessary to optimize oxygen and moisture in the pile, as well as to reduce the presence of anaerobic clumps that may contribute to odors and unfinished compost.

Conventional composting can be enhanced by the introduction of bacterial inoculants. The bacteria (and their enzyme by-products) generate temperatures that reduce remaining pathogens in the biosolids. Via convection, the high temperatures also result in additional oxygen being drawn into the stack accelerating decomposition. The bacterially-modified process can require up to 60 days (rather than the typical 15 days). At least one bacterially enhanced process (Harvest Quest) specifies that final products are lower in labile (leachable) nitrogen and have high levels of sequestered phosphorus, due in part to bacterial chelation.[21] Using an extended timeframe and a higher percentage of bulking agents, their finished compost averages 1.0% total nitrogen and 0.5% total phosphorus, with only 10% of the nitrogen (i.e., 0.1%) being available in the first year following application, with significantly less becoming available in subsequent years. The added costs for either extended composting or bacterial

[18] In February 2024, the Public Employees for Environmental Responsibility (PEER) filed a product liability lawsuit against Synagro, a major manufacturer of biosolids-based fertilizer, for damages caused by toxic chemicals in its product. https://peer.org/pfas-biosolids-fertilizer-damages-lawsuit/

[19] In February 2024, the Public Employees for Environmental Responsibility (PEER) issued a 60-day notice of intent to sue the EPA for failing to enforce the Clean Water Act and end the application of biosolids on US crops. https://www.theguardian.com/environment/2024/mar/12/sewage-us-crop-farming-lawsuit-pfas

[20] Covanta uses Harvest Quest's proprietary Modified Static Aerobic Pile technology.

[21] Harvest Quest achieves a product in which nitrogen is converted to an organic (non-mineralized) and largely non-water-soluble form and water extractable phosphorus is minimized. The finished product releases nutrients at a rate that does not exceed plant uptake. Harvest Quest's approach provides a significant dilution of traceable PFAS compared to the direct utilization of biosolids.

enhancements are modest and include the need for sufficient land area to support continued delivery of biosolids from the WWTP over the additional duration of treatment.

Regardless of composting technique, Florida's high humidity presents an obstacle to optimal performance and efficiency. The optimal moisture content for composting is between 45% and 60%. Above 65% — not uncommon in Florida during the wet season(s), anaerobic conditions develop and compost piles and windows may become significant sources of odors, especially of ammonia. Below a moisture content of 40%, fungi rather than bacteria dominate the decomposer populations and the process of decomposition may be either drawn out or be incomplete. In either case, a higher-quality finished compost may not be produced.[22]

Composting, whether traditional or advanced, creates a product that can build soil health, conserve water, and reduce nutrient loading (especially for nitrogen) relative to direct land application of Class B biosolids. Biosolids, and composted biosolids in particular, contain low to very low levels of water extractable phosphorus (WEP) and thereby pose lower risk to receiving waters than either manures or synthetic fertilizers.[23]

Thermal Processing: Thermal processing of biosolids includes pyrolysis, gasification and incineration. Incineration is not in use in Florida but does have a lengthy history nationally. Incineration can yield between 70% and 80% reduction in solids. The resulting ash — generally free of PFAS — is ordinarily landfilled but can be used in the production of concrete (as a pozzolan). Recovery of excess energy is possible. Carbon dioxide, a greenhouse gas, is a necessary byproduct of incineration.

Pyrolysis is the combustion of biosolids in an anaerobic (no oxygen) environment. Depending on the operating temperature(s) of the process, the molecules containing carbon will fractionate into smaller, simpler molecules. Methane (another greenhouse gas) is a key byproduct but is routinely captured, a portion of which may be fed back and ignited to provide the heat necessary to maintain the pyrolysis process.

Biochar, a charcoal-like product, is the solid residue of the pyrolytic process and is used as a soil amendment. The soil enhancing characteristics of biochar depend on the feedstock and the treatment temperature. The general attributes of biochar include improving soil health, raising soil pH, remediating polluted soils, sequestering carbon, lowering greenhouse gas emissions, and improving soil moisture.[24]

Gasification builds upon the process of pyrolysis by increasing the amount of oxygen (or steam) at the back end of the process, thereby increasing the energy content of the synthesized methane and reducing the carbon content of the bio-char residuals. The process is similar to that for the production of coal gas or town gas (which used coal rather than biosolids for the carbon source).

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[22] Outside of extreme conditions, Harvest Quest specifies that its proprietary methods, facility management and use of corrective procedures allows operation regardless of climate conditions. For conventional composting, a roof to control rain input adds costs (facilities in Lee County and Hillsborough County serve as examples).

[23] Biosolids treated through a biological phosphorus removal (BPR) or similar process, may have increased levels of WEP as phosphorus is concentrated into the solid fraction of biosolids in a more water-soluble form.

[24] https://www.climatehubs.usda.gov/hubs/northwest/topic/biochar#:~:text=Biochar%20is%20a%20stable%20solid,stalks%2C%20manure%2C%20etc.)

Both pyrolysis and gasification require dewatering and dehydration to ensure that controlled combustion can proceed. Depending on efficiency (affected by moisture) pyrolysis can reduce total volume (weight) by 30% to 55%. Gasification as a follow-on procedure can yield reduction in volume from 55% to 65%. As stated above, incineration, which leaves no biochar and only ash, eliminates 70% to 80% of the original volume. Preliminary research suggests that with each of these three technologies there is approximately 100% reduction of volatile solids in the source biosolids and as a result no concentrations of PFAS remain.[25]

The biochar residuals from pyrolysis and gasification have documented beneficial uses, including as (1) a soil amendment for agriculture, horticulture and landscaping, (2) feedstock for facilities that continue to use coal, and (3) feedstock for producing activated carbon, used in a variety of filters such as air purifiers and drinking water filters. The global market for biochar was $2.0 billion in 2021, of which Europe and North America comprised about 70% based on production of at least 66,000 tons.[26] Agriculture is expected to use about 70% of all biochar produced.

Magnetic biochar is a composite material incorporating magnetic materials (e.g., Fe_3O_4) that permits the separation from aquatic media after use and allows re-use of the biochar. The material has demonstrated effectiveness in reducing contaminants from wastewater (i.e., it can be used at earlier in the wastewater treatment train, reducing metals and contaminants in biosolids or biosolids byproducts).[27]

Economics of Select Biosolids Management Practices

The economic analysis conducted examined direct, indirect and non-market costs and benefits using published data, adjusted for inflation. It is emphasized that the majority of information is dated and therefore some caution is warranted. The following tables summarize the classes of cost factors evaluated:

TABLE 14. COST COMPONENTS FOR COST-BENEFIT ANALYSIS

Direct Costs	Indirect Costs	Non-Market Costs
Land Costs	Property Value Impacts	GHGs from Transport
Design & Permitting Costs	Potential Public Health Impacts	GHGs from Landfilled Biosolids
System Purchase (CAPEX)	Loss of Nutrient Input to Agriculture	GHGs from Land-Applied Biosolids
O&M / Repair (OPEX)	Loss of Landfill Capacity	Well Contamination
Replacement (Life-Cycle)		Shadow Price of Nutrient Pollution (N)
De-Watering & Drying Costs		Shadow Price of Nutrient Pollution (P)
Landfilling of Biosolids & Byproducts		
Transport of Biosolids		
Spreading of Biosolids		

Source: Appendix H

[25] Water Environment & Technology, April 2022.
[26] https://www.psmarketresearch.com/market-analysis/biochar-market#:~:text=in%202021%2C%20North%20America%20and,availability%20and%20high%2Dvolume%20consumption.
[27] https://www.sciencedirect.com/science/article/abs/pii/S0960852423012142?casa_token=liiHXpWPk4AAAAAA:WkUtUNpFkU3avBLDZtUDyPO129Uzs6o3G-gXrS7_PV3GDKAfGb-98IoYVyMC0LZKiHH8QH0Nhols

TABLE 15. BENEFIT COMPONENTS FOR COST-BENEFIT ANALYSIS

Direct Benefits	Non-Market Benefits
Ammonia Solution	WTP for Surface Water Quality / Clarity
Recovered Phosphorus	Soil Organic Matter
Electric Revenues	
Compost Revenues	
Avoided Costs for Fertilizer	
Avoided Treatment Costs - N	
Avoided Treatment Costs - P	
Avoided Landfill Costs	
Residual Value	

Source: Appendix H

The following table summarizes the direct costs and benefits only (adjusted for inflation and discounting): these are the more readily quantifiable, predictable and scalable considerations.

TABLE 16. DIRECT COSTS AND BENEFITS, 10-YEAR HORIZON, 1000 DRY TONS

Practice	Direct Costs	Direct Benefits	Net Benefits
Landfill Only	$2,958,506	$2,835,228	($123,278)
Land Application Only (Class B)	$4,542,880	$1,000,101	($3,542,778)
Conventional Composting Only	$8,300,924	$3,830,851	($4,470,073)
Conversion to Class AA	$11,175,738	$4,334,893	($6,840,845)
Extended Composting	$8,361,408	$3,907,222	($4,454,185)
Sedron-Varcor	$6,245,152	$4,901,823	($1,343,329)

Source: Appendix H

The direct costs of landfilling, which include the tipping fee and local transportation, is cheapest in terms of direct costs and as a result has the smallest losses. The costs for conversion to Class AA biosolids are significant and derive from a DEP Statement of Estimated Regulatory Costs, which may have overstated the true impact. The larger value for direct costs results in the smallest of the net benefits among the practices reviewed.

The following table summarizes the indirect and non-market costs and benefits only (adjusted for inflation and discounting): these factors may be less quantifiable and literature values (e.g., dollars per pound of nitrogen removed, per year) can vary. Conservative (i.e., least among the studies and reports reviewed) were generally used provided the context of the study was similar to the scope of this assessment.

TABLE 17. NON-MARKET COSTS AND BENEFITS, 10-YEAR HORIZON, 1000 DRY TONS

Practice	Indirect and Non-Market Costs	Non-Market Benefits	Net Benefits
Landfill Only	$2,394,034	$0	($2,394,034)
Land Application Only (Class B)	$11,650,094	$80,605	($11,569,489)
Conventional Composting Only	$4,484,921	$1,398,930	($3,085,991)
Conversion to Class AA	$2,823,001	$978,951	($1,844,051)
Extended Composting	$650,185	$2,218,927	$1,568,741
Sedron-Varcor	$762,961	$1,996,639	$1,233,679

Source: Appendix H

Here, the non-market costs (negative economic impacts) are greatest for land application; no non-market benefits were assignable. The indirect and non-market costs for high-quality, extended composting and use of vapor recompression and distillation technology were nominal in comparison. More significantly, however, were the non-market benefits for these same practices. Both yield positive non-market benefits over the 10-year horizon of analysis.

The following table reflects all costs and benefits considered and should be considered a reflection or proxy for the total societal costs of managing biosolids in Florida.

TABLE 18. SUMMARY OF TOTAL SOCIETAL COSTS AND BENEFITS ($ MILLIONS), 10-YEAR HORIZON, 1000 DRY TONS

Practice	Total Costs	Total Benefits	Benefit-Cost Ratio	Ratio Relative to Land Application
Landfill Only	$5.35	$2.84	0.53	7.9
Land Application Only	$16.19	$1.08	0.07	1.0
Conventional Composting Only	$12.79	$5.23	0.41	6.1
Conversion to Class AA	$14.00	$5.31	0.38	5.7
Extended Composting	$9.01	$6.13	0.68	10.2
Sedron-Varcor	$7.01	$6.90	0.98	14.7

Source: Appendix H

Table 18 provides (a) the benefit to cost ratio, a common indicator of economic value or contribution, and (b) a ratio of the benefit-cost ratio each practice *relative* to that for land application of Class B biosolids. The benefits-cost ratio for land application is small, reflecting its significant non-market impacts (environmental externalities); that of the Sedron-Varcor vapor recompression and distillation approaches 1.0. Benefit-cost ratios greater than 1.0 imply an economic benefit to the practice and one that is economically justifiable. Regardless, based on the available data, all practices have ratios smaller than 1.0 and can be considered a net cost to society.

The "ratio of ratios" offered provides a supplemental means to look at the in-use practices considered. All of the biosolids management alternatives are economically superior to land application of Class B. Significantly, the relative ratios for extended composting and the vapor recompression and distillation practices are greater than landfill (which benefits from low direct costs), conventional composting and conversion to Class AA (without composting).

Conclusions and Recommendations

This study was undertaken to test two primary concerns:

- whether the land application of Class B biosolids impacts can be correlated with impacts to receiving water bodies, and
- whether the land application of Class B biosolids represents a circumstance of environmental injustice, where the generators of biosolids are imposing environmental or societal costs on receiving communities.

To address these concerns, the study was charged with a literature review, assessment of applicable laws and regulations, the development of a GIS to examine data regarding the spatial relationships

between generators and receivers of biosolids, an assessment of the costs of managing biosolids, and to propose recommendations to remedy impacts or environmental injustice, should these be demonstrated.

The study draws the following conclusions related to the management, environmental impact, societal impact and economics of biosolids in Florida.

Biosolids Management in Florida

The study addressed the recent (through 2021) characteristics of Florida's basic approaches to the majority of the biosolids produced, with an emphasis on state regulation (through 2023) and the nature of inter-county-transfers of Class B material.

- Biosolids are a necessary byproduct of the conventional treatment of wastewater. As Florida's population grows, so will its generation of biosolids and the need to manage them.
- In Florida, biosolids are broadly managed via landfilling, land application, and composting. While the total spatial extent of landfills and land application sites is small and the spatial impacts of biosolids disposed by these methods (including water quality and associated externalities) are modest, more fully composted biosolids are distributed broadly across Florida's landscape with poorly understood consequences for protecting receiving waters.
- The quantities and chemical characteristics of produced biosolids are tracked (if imperfectly) at the point of generation, i.e., the reporting utilities in conjunction with the U.S. Environmental Protection Agency. The quantities and characteristics of Class B biosolids that are land applied are tracked via the Florida Department of Environmental Protection' permitting process. The quantities of Class AA biosolids are not tracked using a manifest system. Once these biosolids are incorporated into fertilizer or soil amendments the resulting quantities are only estimated by the Florida Department of Agriculture and not tracked as to point of sale or use.

Environmental and Societal Impacts of Biosolids

- As a matter of current Federal and State law, biosolids – regardless of how managed – are not required to be 100% free from pathogens, heavy metals, nutrients, or chemicals of emerging concern, including per- and polyfluoroalkyl substances (i.e., PFAS, one of a number of "forever chemicals"). Each regulatory class of biosolids is determined by the residual concentrations of these pollutants at the point of production. Without complete sequestration or elimination of such contaminants, land application in particular ensures that some measure of metals, nutrients, and CECs will end up in receiving waters.
- Information regarding the impacts of land applied Class B biosolids on groundwater is lacking; the impacts on surface waters is beginning to be understood.
- There is a statistically significant nexus between the land application of Class B biosolids and the likelihood that a nearby waterbody is impaired for nutrients (per Florida's designation process). There is support for concluding that phosphorus concentrations in groundwater in the confined aquifer is greater under land application sites. This is not explicitly a cause-and-effect relationship; many other factors and sources contribute to an impaired designation, as indicated by the assessment of land cover. These factors include the degree of urbanization of the landscape (with its own characteristics of nutrient pollution loading), the degree of improved pasture (which may involve application of other fertilizers), slope/gradient and depth to water table (both of which contribute to accumulation of nutrients), among others. In sum, the effect

of land applied biosolids alone on water quality is problematic to determine without fully controlling for other factors, which was beyond the scope of study here.

- There is no clear nexus between the land application of Class B biosolids and environmental justice as is commonly considered. With few exceptions, the large variability of Florida's population as to income, ethnicity and age precludes a statistically significant conclusion that receiving areas are poorer, less racially categorized as white, or more vulnerable due to age than the counties that export biosolids. There are several one-to-one relationships of biosolids producer and receiver (as opposed to many-to-one, or one-to-many) where income levels are different – and lower in the receiving county. These instances stand as individual facts but do not support a general statement that biosolids producers are imposing externalities tied to income or race on receiving counties.
- While demographic data do not support a broad premise of environmental injustice imposed by biosolids transfers at the state-wide level, data regarding the raw movement of material among a few counties suggest the issue is more complicated and warrants a more refined approach to the issue.
- Among those reporting fully, the number of counties exporting any portion of the biosolids they generate is 38. The number of counties receiving biosolids is 23. While these numbers suggest some degree of balance or equity in distribution, as of 2022, Osceola County receives 73% of the state's transferred biosolids. The magnitude of Class B land application operations in Osceola is driven by the availability of large areas of improved and unimproved pasture, the willingness of agricultural operators to receive and spread biosolids at no cost (other than the internal costs of storage and spreading), and the county's location at the edge of the area designated by the Florida Legislature and DEP rule for stricter nutrient standards around Lake Okeechobee. While large portions of Osceola County lie within the SFWMD, the area receiving biosolids lies within the SJRWMD. Based on its conclusion that biosolids contribute to water quality issues, the State has effectuated the transfer of pollution not just from urban areas to rural but specifically from one water management to another (and from one watershed to another).

Economics of Biosolids

- Other than collecting and treating leachate within landfills, the current framework for the pricing of biosolids disposal does not address any environmental externalities (imposed societal costs) fairly attributable to the land application of Class B biosolids. To the extent pollution from biosolids management is addressed, directly or indirectly, such costs are paid for by the public (primarily via State programs funded through general revenue). Unless subject to an active BMAP process, the costs of stream or lake restoration are not addressed by those conducting land application and remediation under a basin plan for an impaired waterbody would generally be engendered via a reduction in use of biosolids (to the degree that biosolids were a substantive source of total loading). The cost then would be a reduction in income tied to agricultural yield, if any were to occur due to the reduction or elimination of biosolids.
- To the extent that Class B (and Class AA) biosolids contribute to exceedances of nutrient TMDLs (or TMDLs for parameters such as dissolved oxygen or suspended solids that may be driven by algal growth stimulated by elevated nutrients) direct remedial costs are imposed on all other contributors to loads that may have otherwise been avoided.

- There are no literal 'out-of-pocket' costs for those who receive biosolids; however, the added costs for transporting biosolids to other counties is captured through utility billing or other fees for wastewater services.
- Of the predominant economically viable means of processing biosolids, treatments involving vapor recompression and distillation technology appears to be the most cost-effective, followed by advanced levels of composting that successfully reduce or sequester nutrients (and CECs) and thereby impose smaller public costs. Waste-to-energy (WTE) options address some concerns, but not all, and the capital costs are considerable. The spectrum of WTE methods can result in the reduction of PFAS, but incineration in particular presents tradeoffs such as increased dioxins and furans.

The dynamics of Class B biosolids management in Florida can be summarized simply:

[1] The total volume of biosolids requiring management continues to grow.

[2] A small number of counties, dominated by Osceola and followed by Brevard and Polk, accept a disproportionate share of Class B biosolids generated.

[3] Land application of Class B wastewater residuals is statistically correlated with surface water quality impairment in select watersheds. Land application of Class AA products can be assumed to contribute to the larger statewide challenges of lake and stream pollution from nutrients, but documenting this and conducting a statistical assessment of correlation for Class AA was beyond the scope of study.

[4] Based solely on the locations of impacted waterways, the environmental costs of land application are borne more heavily by the communities receiving biosolids. This inequity among counties will increase without measures to offset the economic losses, which are dominated by reductions in value for developed properties adjoining waterways impacted by Class B application.

Based upon the findings of this study, biosolids management, and the land application of Class B biosolids in particular, warrants amendments to both Florida law and DEP rule and practice to better ensure that the beneficial attributes of biosolids are more effectively deployed while the negative aspects of biosolids are reduced. The following recommendations recognize that as byproducts of publicly owned treatment works (POTW) operations, biosolids are largely a public resource and that the distribution of public costs (impacts) and benefits is fundamentally a public responsibility. The following recommendations are offered to rectify some of the management gaps, equity concerns and economic inefficiencies identified in the study:

- There is a need for a definitive, comprehensive and responsible binding solution that incorporates all stakeholder input.
- Beyond the use of biosolids as a component of landfill daily cover (which itself contributes to greenhouse gas emissions) the landfilling (i.e., burial) of biosolids is an ineffective use of the resource. Recognizing that the practice is relatively cheap and there may be institutional inertia, the societal costs of methane generated and risks from contaminated leachate outweigh any cost savings. Therefore, landfilling should assume a smaller role as a management option over time, perhaps limited to the smallest communities for which more advanced technologies or transfer to a regional processing facility would be cost-prohibitive.

- Within its BMAPs for impaired waters, the DEP should prioritize the non-renewal or phasing out of biosolids land application permits in conjunction with agricultural BMPs that will reduce total loadings of nutrients. While the loss of biosolids presents the possibility that farmers will increase their respective use of chemical fertilizers to offset the reduction in added nutrients, financial incentives for more aggressive use of BMPs may ameliorate any production or yield impacts. The University of Florida's Institute for Food and Agricultural Science could be charged (and funded) by the Legislature to identify cost-effective means to maintain crop (or animal weight) yield with progressively less use of Class B biosolids and minimal substitution or replacement by conventional fertilizers. Substantive losses in income can be addressed by several means:
    - Despite the agronomic benefits of the nutrients and humic material received in the form of biosolids, the intercounty transfer of biosolids represents an imposed cost on receiving communities. The classical economic remedy for this condition is referred to as a Pigovian Tax, i.e., a tax on market transactions that create a negative externality or cost borne by individuals not directly involved in the transaction.[28]
    - Taxes do have a negative connotation. The monies described as Pigovian could be collected as an assessment or fee, based on a wastewater account, rather than as a tax based on the level of usage. The State collects a variety of uncontroversial fees for environmental purposes (e.g., tire and battery disposal); biosolids management may be handled similarly. The funds could be administered through a trust fund and thereby avoid impacting general revenues.
- In 2023, the State approved a pilot program for innovative technologies that render biosolids less environmentally impactful. The program should be evaluated its effectiveness in promoting innovative (and successful) approaches to biosolids management and to determine if additional funding is needed to scale-up promising approaches or to tailor proven approaches to different parts of the state and different biosolids markets.
- The outcomes of recent filed Clean Water Act litigation against the EPA are pending as of this study. Florida has a large population and CECs in the environment have been correlated (elsewhere) with population and non-point pollution (rather than by point source industrial discharge alone).[29] CECs (with an emphasis on PFAS) can be expected to become a larger consideration in biosolids management as studies document both the breadth of human exposure and the risk. Florida should employ the "precautionary principle" to foster technologies that minimize residual PFAS in biosolids, regardless of whether landfilled, land applied, or composted for distribution in fertilizers and soil supplements.

[28] For example, the societal costs of waterways impacted by the land application of biosolids would be added to the utility costs for wastewater management. In this manner, those directly responsible for the impacts bear the costs for waterway restoration, or, should there be an impact to property values or recreational use, the tax paid would compensate for the loss in users' value. The increase in costs to the generators is then an incentive to shift to technologies that produce fewer impacts.

[29] A three-year study by Florida International University and Bonefish & Tarpon Trust discovered pharmaceutical contaminants in the blood and other tissues of bonefish in several Florida coastal waters. https://www.bonefishtarpontrust.org/blog/2022-02-02-pharmaceutical-contaminants-discovered-in-south-florida-bonefish/

- While any regulatory changes at the EPA regarding PFAS, whether for drinking water or biosolids, will pass down to the states, it would benefit Florida (with an effective population of 24 million people) to ensure it has a full understanding of the regulatory measures for biosolids undertaken or being actively considered by other states. A required change in management options and choices will not occur overnight, but the State can be better prepared to coordinate and partner with cost-effective and environmentally effective options.
- The DEP could be charged more directly to serve as a state-wide clearinghouse for biosolids management, rather than collecting reported information (and issuing permits). Permit renewals can be better tied to dutiful reporting to minimize data gaps.
- Based on this study, additional research about biosolids management and impacts is warranted in six subject areas to support better policy:
    - biosolids data merit more accurate collection, reporting compliancy, and reliable tabulation;
    - the costs and benefits of the several categories of management at both local and regional scales (i.e., county-level and multi-county);
    - other scalable technologies that may produce recoverable and reusable products while nullifying the risks posed by heavy metals and CECs (including PFAS) in wastewater residuals;
    - biosolids management and disposition fee structures that shift environmental and related societal costs onto the producers of biosolids from receiving areas while reducing the fiscal impact on state general revenues and water management district ad valorem directed at water quality measures;
    - assessing more completely the export of nutrients from the range and characteristics of sites receiving biosolids; and
    - optimizing the nutrient content and application of Class AA biosolids for the Florida landscape for all major uses (i.e., residential, improved pasture; horticultural), reflecting existing (and reasonably projected) water conditions within BMAPs, including consideration of limitations on use by area and season.

Each of the above research targets should be supported and adequately funded through a comprehensive Legislative effort to address knowledge gaps in biosolids management. The sooner such research can be conducted and brought to the decision-making processes of the Legislature and the DEP (the regulators) and the wastewater utilities (the regulated) the sooner the continued and growing risks of biosolids in Florida can be faced.

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APPENDICES

Appendix A. Wastewater and Biosolids Production Data

Appendix B. EPA POTW Biosolids Data, 2021

Appendix C. Biosolids Intercounty Transfer Matrix

Appendix D. Demographic and Socio-economic Statistical Output

Appendix E. Water Quality Statistical Output

Appendix F. Estimated Runoff of Labile Nutrients from Biosolids

Appendix G. Estimated Leaching of Labile Nutrients from Biosolids

Appendix H. Cost-Benefit Analysis

Appendix I. Florida Laws Governing Biosolids

Appendix J. Annotated Project Bibliography

Appendix A. Wastewater and Biosolids Production Data

Resident Population

Biosolids production is inextricably linked to wastewater generation, and wastewater generation is in turn driven by population. Florida's population continues to grow, and wastewater (and therefore biosolids) generation can be assumed to increase roughly linearly with population. Between 1990 and 2020, Florida's population grew at rate of 1.72% per year although the rate is predicted to decline to an average of 1.62% in the current decade.

TABLE 19. FLORIDA'S POPULATION

Year	Population (millions)
1990	12.94
2000	15.98
2010	18.80
2020	21.60
2030*	24.42
2040*	26.36

* Projected by EDR, 2023

Source: http://edr.state.fl.us/content/population-demographics/data/index-floridaproducts.cfm

Tourism

Tourism is significant in Florida and cannot be neglected as a component of demand for water use and resulting wastewater treatment and biosolids generation. Detailed estimates for the most recent years, based on surveys and supporting methodologies, are available through Visit Florida.[1] Visitation in 2020 was less than 80 million because of the pandemic and not included in the table below (or the following estimation of effective state population). During 2017—2022, tourism grew at a rate of 2.98% per year. i.e., faster than the resident population and therefore important to incorporate into projections.

TABLE 20. RECENT TOURISM IN FLORIDA

Year	Estimated Tourism (millions of visitors)
2017	118.8
2019	131.1
2021	122.4
2022	137.6

Source: https://www.visitflorida.org/resources/research/

While the lengths of domestic and overseas visits to Florida have declined slightly over time, weighted data available for 2017 yield an average stay of 5.0 nights. Assuming the average of 127.5 million visitors (2017-22, excluding 2020), tourism conservatively represents the equivalent of 1.75 million full-time residents, nearly 8.1% of the state's census-measured population in 2020.[2]

[1] https://www.visitflorida.org/resources/research/research-faq/
[2] The estimated equivalent population for 2022 is 1.88 million.

Using the average of the US Census estimate for 2022 (22.245 million[3]) and that of the Florida Office of Economic and Demographic Research (22.276 million[4]), the estimated resident population of Florida for 2022 is 22.26 million.

- For purposes of this study, a base effective state population of 24.01 million is assumed, including a conservatively averaged population equivalent population for tourism.
- Over time, the need to manage biosolids – including its costs and impacts -- will be proportional to the combined rates of increase in the numbers of Florida's residents and visitors.[5]

Wastewater Generation

Florida's 'rule-of-thumb' for wastewater generation is 100 gallons per person per day (gppd)[6], which includes *non-residential use*.[7,8] Such wastewater is assumed to be derived from all interior water use (e.g., toilet, kitchen sink and showers). Based on this rough number, at 24.01 million individuals the volume of wastewater produced in Florida is approximately 876.3 billions of gallons per year (bgy), or 2.4 billions of gallons per day (bgd).

It is feasible to refine this coarse estimate of wastewater generated (and therefore biosolids produced). DEP's currently available data provides some detail on a total of 2,376 permitted wastewater facilities in Florida.[9] The majority of these facilities are private and largely for commercial and industrial purposes and are not significant generators of biosolids. Potentially relevant to this study, there are 421 facilities under the "authority", "county", "municipal", "district" and "state" facility ownership classes. These are reported to total 2,582 mgd (2.58 bgd) in permitted capacity, close to the 2.7 bgd that DEP reports on its webpage of general information about wastewater treatment.[10] Treated effluent (flow) data by facility are not readily available via the DEP site. However, the DEP estimates that among all facilities about 1.5 bgd of effluent are treated, or about 55.6% of the permitted capacity. Applying that value would yield approximately 1,434 mgd in treated effluent from which biosolids volumes could be potentially derived.

Among the 421 facilities identified above, excluding power generation and other industrial uses, there are 168 wastewater facilities for which permitted capacities are provided, and of these there are 137

[3] https://www.census.gov/library/stories/2022/12/florida-fastest-growing-state.html#:~:text=Florida's%20population%20increased%20by%201.9,its%201946%20population%20of%202%2C440%2C000.
[4] http://edr.state.fl.us/content/population-demographics/data/index-floridaproducts.cfm
[5] Per person water use (and wastewater generation) for hotels is typically higher than that for residential use (exclusive of outdoor irrigation). Water 2022, 14(22), 3726; https://doi.org/10.3390/w14223726
[6] https://floridadep.gov/water/domestic-wastewater#:~:text=Each%20person%20in%20Florida%20generates,aesthetic%20appeal%20of%20our%20waterways.
[7] The National Environmental Education Foundation (NEEF) estimates 87 gppd for residential use in Florida (https://www.neefusa.org/story/water/home-water-use-united-states#Florida)
[8] For contrast, detailed sewer services use and billing data for the Village of Bal Harbour suggests wastewater generation at 164 gppd, but this would include hotels and tourism use, not otherwise isolatable for several large properties in the Village.
[9] https://qlik.dep.state.fl.us/anon/sense/app/e7e83275-ce98-48d5-ac71-d3dd820fbde2/sheet/8e215150-ce72-4f3e-ab38-93e7cd67b2ac/state/analysis
[10] https://floridadep.gov/water/domestic-wastewater/content/general-facts-and-statistics-about-wastewater-florida

facilities (i.e., 87% of the total) with permitted capacities greater than 1.0 mgd. The total permitted capacity of these larger facilities is 1,718 mgd, or 99% of the permitted capacity identified. If the above coarse estimate of the ratio of treated flow to capacity were applied, there are approximately 954 mgd in treated wastewater flow of which 944 mgd derives from facilities permitted for 1.0 mgd or greater.

- For purposes of this report, 944 mgd of treated effluent is assumed to be the primary basis for Florida's current biosolids production and management needs. This volume of effluent equates to 344.6 bgy.

Biosolids Production

The characteristics of wastewater effluent vary depending upon nature of the inflow and the treatment process being used: biosolids concentrations may be as high as 2% of the original volume of wastewater (about 17.5 bgy based on the upper bound estimate of 876.3 bgy, but 6.9 bgy based on the more detailed estimate above) but are often less than 1% of wastewater volumes. In turn, these biosolids will have between 93% and 97% water content. Using the assumed rate of 344.6 bgy and the range of percentages for water content suggests current statewide biosolids production between 103.4 and 241.2 millions of gallons annually (mgy). The quantity reflects the coarse volume of biosolids that are produced *prior to further treatment* or disposition. The quantity likely addresses biosolids generated at the 137 wastewater treatment facilities indicated above as well as a portion of material received from individual on-site treatment and disposal systems (i.e., pumpouts from conventional septic tanks and drainfields).

While biosolids generated at wastewater treatment facilities are broadly monitored for volume and final disposition, a significant share of wastewater (and associated biosolids) is processed by individual onsite treatment and disposal systems (OSTDS), conventionally known as septic tanks and drainfields. Through the Florida Water Management Inventory originally conducted by the Department of Health, Bureau of Onsite Sewage Systems, Florida estimated there were approximately 2.6 million such systems as of 2019.[11] However. as with general population, this number has increased, especially in rural counties where centralized wastewater infrastructure is absent. The most recent estimate (2023) is greater than 2.7 million.[12]

A nominal share of septic tanks is routinely pumped out to maintain performance and to minimize the risk of drainfield failure.[13] More typically, sludge from septic tanks is removed when there has been a system failure (i.e., a backup). Removed sludge (especially if done by a licensed commercial firm) is brought to a nearby WWTF for treatment. While typical drainfields may function 25 years or longer, industry and DOH/DEP data suggest a typical lifespan between 10 and 20 years. For purposes of discussion, a 10% failure rate (i.e., once every ten years) is assumed.[14] With contemporary tanks averaging 1,250 gallons and the 2% proportion of total volume, biosolids removed and delivered to treatment facilities are approximately 6.5 mgy, or between 2.7% and 6.3% of Florida's production from central wastewater treatment facilities.

[11] https://www.floridahealth.gov/environmental-health/drinking-water/flwmi/index.html
[12] https://ccs.eng.ufl.edu/saving-time-and-money-to-convert-from-septic-to-sewer-systems/
[13] Tank failure itself is rare; replacement rates vary between 20 and 50 years depending on tank type (i.e., concrete vs fiberglass) and environmental conditions.
[14] Florida data report an annual average of 17,785 septic system repairs during FY10 through FY20. This corresponds to just 0.7% of the number of estimated systems, i.e., a failure rate of less than 1 in 100.

- Added to the above estimate, the expected (average) production of biosolids prior to further treatment from all sources is 178.8 mgy, or an average of 7.45 gallons of primary sludge per person per year.[15]
- At the estimated volume of 876.3 bgy for untreated effluent, the estimated annual quantity of biosolids produced is 365,400 dry tons.[16] This volume is about 7.5% greater than DEP's published estimates in 2018 and consistent with equivalent population growth during the past four years.
- Data are not directly available to determine whether the share of OSTDS septage being converted to Class AA has increased over time.

[15] This compares reasonably with 43 lb/person/yr (about 5.4 gallons described in industry literature): https://www.thewastewaterblog.com/single-post/2016/09/28/wastewater-characteristics

[16] Using 1% solids. Dry tons are calculated as wet tons of primary sludge times the percent solids.

Appendix B. EPA POTW Biosolids Data, 2011

Facility Name	Amount of Biosolids Generated	Management Practice Type(s)	Amount of Biosolids Managed - Land Applied	Amount of Biosolids Managed - Other Management Practice	Pathogen Class(es)
MIAMI-DADE COUNTY - PUBLIC WORKS DEPARTMENT	18,017	Land Application	18,017		Class B
MDWASA SOUTH DISTRICT WWTF	14,730	Land Application	14,727		Class B
SEACOAST UTIL-PGA WWTP	13,717	Land Application	13,717		Class A EQ
BROWARD COUNTY WATER AND WASTEWATER SERVICES	13,629	Land Application	11,890		Class B
SOUTHEAST COUNTY LANDFILL	12,660	Land Application	12,660		Class A EQ
BUCKMAN BIOSOLIDS TREATMENT FACILITY (BTF)	12,277	Land Application, Other Management Practice	10,039	2,238	Class A, Class B, Not Applicable
CITY OF HOLLYWOOD	12,069	Land Application, Other Management Practice	11,481	588	Class A EQ, Class B
CITY OF TAMPA - DEPARTMENT OF SANITARY SEWERS	9,210	Land Application	9,210		Class B
ORLANDO - CONSERV II WRF	7,296	Land Application	7,296		Class A EQ
ORLANDO, CITY OF	6,498	Other Management Practice		6,498	Not Applicable
PINELLAS COUNTY UTILITIES	6,109	Land Application	6,109		Class A
EMERALD COAST UTILITIES AUTHORITY	5,560	Land Application	5,560		Class A, Class B
FORT LAUDERDALE - G T LOHMEYER WWTP	5,366	Other Management Practice		5,367	Class A
OCUD/SOUTH WRF	5,296	Land Application	5,296		Class B
HILLSBOROUGH COUNTY WATER DEPARTMENT	4,721	Other Management Practice		4,721	Class A
ST. PETERSBURG, CITY OF - SOUTHWEST WRF	4,375	Land Application	4,375		Class A
SOUTH CENTRAL REGIONAL WW TRT & DISPOSAL BOARD	4,088	Other Management Practice		3,709	Class A
TWA - SOUTH BERMUDA	3,902	Other Management Practice		3,902	Class A EQ
HILLSBOROUGH COUNTY PUBLIC UTILITIES DEPARTMENT	3,601	Other Management Practice		3,601	Class A EQ, Class A, Not Applicable
MANATEE COUNTY SOUTHEAST REGIONAL WWTF	3,563	Land Application, Other Management Practice	3,316	247	Class A EQ, Not Applicable
GAINESVILLE REGIONAL UTILITIES	3,280	Other Management Practice		3,309	Not Applicable
THOMAS P. SMITH WWTP	2,972	Land Application	2,972		Class A EQ
HILLSBOROUGH COUNTY PUBLIC UTILITIES DEPT.	2,505	Other Management Practice		2,505	Class A, Not Applicable, Class A EQ
SOUTHWEST WRF	2,293	Other Management Practice		2,293	Not Applicable
CITY OF BOCA RATON	2,254	Other Management Practice		2,254	Class A
HILLSBOROUGH COUNTY PUBLIC UTILITIES DEPARTMENT	2,249	Other Management Practice		2,249	Class A EQ, Class A, Not Applicable
HOLLY HILL, CITY OF	2,161	Land Application	2,161		Class B
CITY OF MACCLENNY	2,036	Other Management Practice		1,847	Class B
BAYOU MARCUS WATER RECLAMATION	1,855	Other Management Practice		1,855	Class A
SANFORD, CITY OF	1,813	Other Management Practice		1,813	Not Applicable
LOXAHATCHEE ENVIRONMENTAL CONTROL DISTRICT - WWTP	1,745	Other Management Practice		1,744	Not Applicable
SUNRISE NO 3 WWTP (SAWGRASS)	1,698	Other Management Practice		1,698	Class A EQ
MIRAMAR, CITY OF WWTF	1,662	Land Application	1,662		Class B
MANATEE COUNTY SOUTHWEST REGIONAL WWTP	1,575	Other Management Practice		1,575	Not Applicable
CITY OF LARGO. WWTP	1,553	Other Management Practice		1,553	Class A EQ
CITY OF PANAMA CITY BEACH	1,532	Land Application	1,532		Class B
TWA - SANDHILL ROAD WWTF	1,455	Other Management Practice		1,455	Class A EQ
CITY OF CLEARWATER PUBLIC UTILITIES DEPARTMENT	1,425	Land Application	1,425		Class A EQ
CITY OF PLANT CITY	1,318	Other Management Practice		1,318	Class A
CITY OF SARASOTA	1,292	Other Management Practice		1,292	Class A
CITY OF CAPE CORAL	1,226	Other Management Practice		1,226	Not Applicable
NEW PORT RICHEY CITY OF WWTF	1,203	Other Management Practice		1,203	Class A
NORTHEAST REGIONAL WWTF	1,168	Other Management Practice		1,168	Class B
MELBOURNE/DB LEE WWTP	1,106	Land Application	1,106		Class B
CITY OF CLEARWATER PUBLIC UTILITIES DEPT.	1,102	Land Application	1,102		Class A EQ, Class B
GAINESVILLE REGIONAL UTILITIES	1,036	Other Management Practice		1,036	Not Applicable
PLANTATION REGIONAL WWTP	1,022	Land Application	1,020		Class B
CITY OF ORMOND BEACH	994	Other Management Practice		994	Class A
FLEMING ISLAND REGIONAL WWTF	951	Land Application	951		Class A EQ, Class B
SANFORD/SOUTH WRF #2	920	Other Management Practice		920	Not Applicable
CITY OF NAPLES PUBLIC WORKS UTILITIES DIVISION	855	Other Management Practice		855	Class A EQ
MARTIN COUNTY TROPICAL FARMS WWTF	851	Other Management Practice		851	Not Applicable
SPENCER'S CROSSING WWTF	831	Land Application	831		Class A EQ, Class B
MELBOURNE, CITY OF	782	Land Application	782		Class B
THREE OAKS WWTF	776	Other Management Practice		776	Not Applicable
TWA/CAMELOT S/D WWTF	756	Other Management Practice		756	Class A EQ
LEE COUNTY UTILITIES	749	Other Management Practice		749	Not Applicable
CITY OF DUNEDIN	747	Land Application	747		Class B
MARGATE,CITY OF WEST WWTP	743	Land Application	743		Class B
VILLAGE OF WELLINGTON WWTP	704	Other Management Practice, Land Application	704	704	Class A EQ
DESTIN WATER USERS, INC.	702	Land Application	702		Class B
FORT MYERS BEACH STP	694	Other Management Practice		694	Not Applicable
MILLER STREET WWTF	678	Land Application	678		Class A EQ
SUNRISE NO 1 WWTP (SPRINGTREE)	653	Other Management Practice		653	Class A EQ
SOUTHWEST REGIONAL WWTP	652	Other Management Practice		652	Class B
PACE WATER SYSTEM, INC. & PACE PROPERTY FINANCE AUTHORITY	648	Land Application	648		Class B
VENICE, CITY OF	612	Other Management Practice		612	Class B
OCALA WRF #2	607	Other Management Practice		607	Not Applicable
TWA/CYPRESS WEST	600	Other Management Practice		600	Class A EQ
MANATEE COUNTY NORTH REGIONAL WRF	594	Other Management Practice		594	Not Applicable
CITY OF LYNN HAVEN	586	Land Application	586		Class B
OCALA WRF #3	560	Other Management Practice		560	Not Applicable
TITUSVILLE, CITY OF	548	Other Management Practice		548	Not Applicable, Class A
VERO BEACH, CITY OF	542	Other Management Practice		542	Class B
HAINES CITY WWTP	525	Land Application	525		Class B
PEMBROKE PINES, CITY OF WWTP	522	Land Application	522		Class A, Class B
NV REGIONAL WASTEWATER TREATMENT FACILITY	505	Land Application	505		Class B
WEST MELBOURNE/RAY BULLARD	504	Land Application, Other Management Practice	371	133	Class B
CITY OF PANAMA CITY	501	Land Application	501		Class B

Appendix B. EPA POTW Biosolids Data (Continued)

Facility Name	Amount of Biosolids Generated	Management Practice Type(s)	Amount of Biosolids Managed - Land Applied	Amount of Biosolids Managed - Other Management Practice	Pathogen Class(es)
RIDAUGHT LANDING WWTF	473	Land Application	473		Class A EQ, Class B
COOPER CITY WEST WWTP	463	Land Application	464		Class B
CITY OF STARKE	453	Other Management Practice		453	Class B
COCOA BEACH, CITY OF	406	Other Management Practice		406	Not Applicable
MARTIN COUNTY UTILITIES NORTH WWTF	402	Other Management Practice		402	Not Applicable
COCOA, CITY OF - COCOA WRF	386	Land Application	386		Class B
LEESBURG, CITY OF	379	Land Application	379		Class B
SOUTH SANTA ROSA UTILITIES SYSTEM WWTF	377	Land Application	377		Class B
EDGEWATER, CITY OF	364	Land Application	364		Class B
CRESTVIEW WWTP	362	Land Application	362		Class B
LEESBURG/TURNPIKE WWTF	354	Land Application	354		Class B
CITY OF OLDSMAR	341	Other Management Practice		341	Class B
NORTH PORT CITY OF WWTP	335	Other Management Practice		335	Class B
PLAYERS CLUB SOUTH WWTF	325	Land Application	325		Class B
PALMETTO, CITY OF	292	Land Application	292		Class B
CORAL SPRINGS IMP DIST WWTF	292	Land Application	292		Class B
CITY OF FERNANDINA BEACH	287	Other Management Practice		287	Class B
TITUSVILLE, CITY OF	281	Other Management Practice		281	Not Applicable
WINTER HAVEN WWTP #2	276	Other Management Practice		276	Not Applicable
MARIANNA CITY OF WWTP	276	Land Application	276		Class B
TOWN OF DAVIE	273	Land Application	273		Class B
TWA/PARKWAY WWTF	267	Other Management Practice		267	Class A EQ
NORTHWEST REGIONAL	214	Other Management Practice		214	Class B
CITY OF PANAMA CITY	203	Land Application	203		Class B
CITY OF PUNTA GORDA WWTP	177	Land Application	644		Class B
CITY OF ALACHUA AWRF	174	Land Application	174		Class B
LIVE OAK WWTF	171	Land Application	171		Class B
GATEWAY SERVICES CDD	160	Other Management Practice		160	Not Applicable
TWA-LAKE MARION	127	Other Management Practice		127	Class A EQ
TOWN OF ORANGE PARK	113	Land Application	113		Class B
TOWN OF DAVIE SYSTEM IV WATER RECLAMATION FACILITY	103	Land Application	103		Class B
TOHOPEKALIGA WATER AUTHORITY	97	Other Management Practice		97	Class A EQ
CITY OF SUNRISE UTILITIES DEPARTMENT - SOUTHWEST WWTF	66	Other Management Practice		66	Class A EQ
1ST SPECIAL OPERATIONS CIVIL ENGINEER SQUADRON	59	Land Application	59		Class B
CITY OF JASPER	50	Land Application	50		Class B
NAS JACKSONVILLE	45	Other Management Practice		45	Class B
WAUCHULA CITY OF WWTF	41	Land Application	41		Class B
MARY ESTHER WWTP	28	Land Application	28		Class B
CITY OF PERRY	28	Land Application	28		Class B
CITY OF BLOUNTSTOWN	24	Land Application	24		Class B
US NAVAL STATION MAYPORT	23	Land Application	23		Class B
DEFUNIAK SPRINGS, CITY OF - WWTP	19	Land Application	19		Class B
GLEN OAKS MHP WWTF	0	Other Management Practice			Not Applicable
TOTALS	171,946		91,751	80,825	

Appendix C. Class B Biosolids Transfer Matrix (Average Annual Tons, 2018-2021)

FROM \ TO	ALACHUA	BAKER	BRADFORD	BREVARD	CALHOUN	CHARLOTTE	CITRUS	COLUMBIA	DIXIE	DUVAL	GADSDEN	GILCHRIST	GULF
ALACHUA	34							23					
BAKER		22											
BAY					899								2,411
BRADFORD			37										
BREVARD				107									
BROWARD				1,006									
CALHOUN					17								
CHARLOTTE													
CITRUS							246						
CLAY		97						17					
COLUMBIA								14					
DIXIE								5	59				
DUVAL										14			
FRANKLIN													4
GADSDEN											10		24
GILCHRIST												73	
GULF													21
HAMILTON													
HARDEE													
HERNANDO							32						
HILLSBOROUGH				160		1,687							
JACKSON													18
JEFFERSON													10
LAFAYETTE													
LAKE				27									
LEVY													
LIBERTY													1
MADISON													
MANATEE				14									
MARION				0									
MARTIN													
MIAMI-DADE				1,362		399							
NASSAU								6					
OKALOOSA													
OKEECHOBEE													
ORANGE				215									
PINELLAS				35									
POLK				4									
PUTNAM													
ST JOHNS								21					
ST LUCIE				85									
SUMTER													
SUWANNEE								19					
TAYLOR													
UNION													
VOLUSIA				351									
WAKULLA													33
WALTON													
N/A				239		504	30			51			470
TOTAL DISPOSED	**34**	**119**	**37**	**3,603**	**916**	**2,590**	**307**	**104**	**59**	**65**	**10**	**73**	**2,991**

Appendix C. Class B Biosolids Transfer Matrix (Continued)

FROM	TO												
COUNTY	HAMILTON	HARDEE	HERNANDO	HIGHLANDS	HILLSBOROUGH	HOLMES	LAFAYETTE	LAKE	LEVY	LIBERTY	MADISON	MARION	NASSAU
ALACHUA									32				
BAKER													
BAY													
BRADFORD													
BREVARD													
BROWARD													
CALHOUN													
CHARLOTTE		0		17									
CITRUS									20				
CLAY													
COLUMBIA													
DIXIE													
DUVAL													
FRANKLIN													
GADSDEN													
GILCHRIST													
GULF													
HAMILTON	51												
HARDEE		0		14									
HERNANDO			331										
HILLSBOROUGH					4								
JACKSON													
JEFFERSON													
LAFAYETTE							3						
LAKE								3					
LEVY									196			247	
LIBERTY										4			
MADISON											16		
MANATEE		0		271									
MARION									177			470	
MARTIN													
MIAMI-DADE													
NASSAU													81
OKALOOSA						281							
OKEECHOBEE													
ORANGE								146					
PINELLAS		0	355	255									
POLK		0	7	151									
PUTNAM													
ST JOHNS													
ST LUCIE													
SUMTER			15										
SUWANNEE													
TAYLOR													
UNION													
VOLUSIA													
WAKULLA													
WALTON													
N/A				2					19				
TOTAL DISPOSED	**51**	**0**	**708**	**711**	**4**	**281**	**3**	**149**	**445**	**4**	**16**	**717**	**81**

Appendix C. Class B Biosolids Transfer Matrix (Continued

FROM / COUNTY	OKEECHOBEE	ORANGE	OSCEOLA	POLK	PUTNAM	ST JOHNS	SUWANNEE	TAYLOR	UNION	VOLUSIA	WALTON	TOTAL GENERATED
ALACHUA				415			94	629	4			1,231
BAKER												22
BAY												3,310
BRADFORD					35							72
BREVARD		0	2,310									2,418
BROWARD		0	16,144	264								17,414
CALHOUN												17
CHARLOTTE				2								19
CITRUS							1					267
CLAY							63	48	1			227
COLUMBIA							110	130	1			254
DIXIE							24	35				122
DUVAL							39	464	1			518
FRANKLIN												4
GADSDEN												34
GILCHRIST							4					76
GULF												21
HAMILTON												51
HARDEE				3								16
HERNANDO												363
HILLSBOROUGH		0	7,205	1,480								10,536
JACKSON												18
JEFFERSON												10
LAFAYETTE							3					5
LAKE		0	193	365								588
LEVY												443
LIBERTY												4
MADISON												16
MANATEE		0	83	1,019								1,388
MARION												648
MARTIN		0	8									8
MIAMI-DADE		0	13,716	766								16,243
NASSAU							41	23				150
OKALOOSA											55	336
OKEECHOBEE	65											65
ORANGE		0	8,416									8,777
PINELLAS		0	566	925								2,137
POLK			4	800								966
PUTNAM					1							1
ST JOHNS						36	139	142	5			343
ST LUCIE		0	369									454
SUMTER												15
SUWANNEE							101	76	3			198
TAYLOR												0
UNION												0
VOLUSIA		0	2,253				17			198		2,819
WAKULLA												33
WALTON											4	4
N/A		0	9,844	150								11,309
TOTAL DISPOSED	**65**	**2**	**61,111**	**6,190**	**35**	**36**	**634**	**1,545**	**15**	**198**	**59**	**83,969**

Appendix D. Demographic and Socio-Economic Statistical Output

Basic statistical parameters for demographic and socio-economic data – minimum, maximum and average -- for Block Groups, statewide (State) and within subwatersheds containing application sites (HUC12/AS)

- Block Group Total Population
  - State min, max, avg. = 0 18,071 1,640
  - HUC12/AS min, max, avg. = 42 11,171 1,730
- Block Group Percent Non-White Population
  - State min, max, avg. = 0% 100% 36.41%
  - HUC12/AS min, max, avg. = 1.92% 94.73% 27.17%
- Block Group Percent Under 5
  - State min, max, avg. = 0% 36.09% 4.81%
  - HUC12/AS min, max, avg. = 0% 26.74% 4.71%
- Block Group Percent Over 60
  - State min, max, avg. = 0% 100% 29.93%
  - HUC12/AS min, max, avg. = 0% 100% 32.90%
- Block Group Median Household Income
  - State min, max, avg. = $0 $250,000 $60,116
  - HUC12/AS min, max, avg. = $0 $173,765 $49,243

Socio-Economic Statistics

The environmental justice assessment starts at the county level. We used several regression techniques to estimate the demographic characteristics of counties that are net exporters of biosolids versus those that are net importers. We also analyzed at this aggregate level the socio-economic profiles of exporting and importing counties. Finally, we run a regression model that combines all these factors to determine whether environmental justice issues exist when other factors that may account for biosolids imports are controlled for. To measure these latter effects, we looked at the total (net) amount of biosolids being applied.

Following this overview, we dig deeper into the specific local effects by allocating biosolid applications to specific sites and measuring demographic characteristics at the Census Block Group level, and environmental impacts across specific watersheds. Biosolids are distributed to these locations under the assumption that application amounts are consistent per acre of permitted land. This allocation process allows us to be much more precise in measuring any local disparities demographically, and to identify the probable effect that applications have on the impairment of local waters after controlling for other potential causal factors.

This analysis explores the relationship between those counties who are purely biosolids exporters (Send Only counties) versus counties that are pure importers (Receive Only) of biosolids. These counties are listed in Table 8. The control group for this analysis are those counties that both import and export biosolids. In short, we find that exporting counties are larger, have higher median income, and are more

diverse, but these differences are not statistically significant. Exporting counties are significantly more population dense, while receiving counties have significantly more Improved Pastureland.

TABLE 21. STRICTLY SENDING AND RECEIVING COUNTIES OF BIOSOLIDS IN FLORIDA

Send Only	Receive Only
Broward	Collier
Franklin	DeSoto
Jackson	Flagler
Jefferson	Highlands
Manatee	Holmes
Miami-Dade	Indian River
Okaloosa	Osceola
Pinellas	
St. Lucie	
Wakulla	

Source: Project Geodatabase

To test the statistical significance of differences across county categories, we estimated the variable of interest, for example median income, as a function of the categorical variables D1 (exporting counties) and D2 (importing counties). with the control expressed as the constant:

$$Y_i = \alpha + \beta_1 D1_{i1} + \beta_2 D2_{i2} + \varepsilon_i \qquad (1)$$

where ***i*** counts the number of counties. In this formulation, $\beta_1 D1$ is the mean difference in the median income of exporting counties relative to the control, which is the mean of median incomes in counties that both send and receive biosolids.

Table 9 reports that the mean of median incomes in control counties is $52,417 (which is clearly significantly different from 0). The median income in biosolids exporting-only counties is $4,205 higher on average (i.e., a mean of $56,622), which is not a statistically significant difference at a 90% confidence interval (CI). The median income of importing counties is $914 lower on average than the control, also not significant at a 90% CI. At a 90% CI exporting counties have significantly higher population density with 727 people per square mile (i.e., 405 persons in the control plus an additional 322 persons per square mile in the exporting category). In contrast, at a CI of 95% counties that exclusively import biosolids have significantly more land devoted to improved pasture than the control group, averaging a total of 116,659 acres compared to the mean of 47,877 in control counties.

TABLE 22. MEDIAN INCOME, PERCENT NON-WHITE, POPULATION DENSITY AND IMPROVED PASTURE MEAN DIFFERENCES FROM COUNTIES THAT SEND AND RECEIVE BIOSOLIDS BY SENDING STATUS

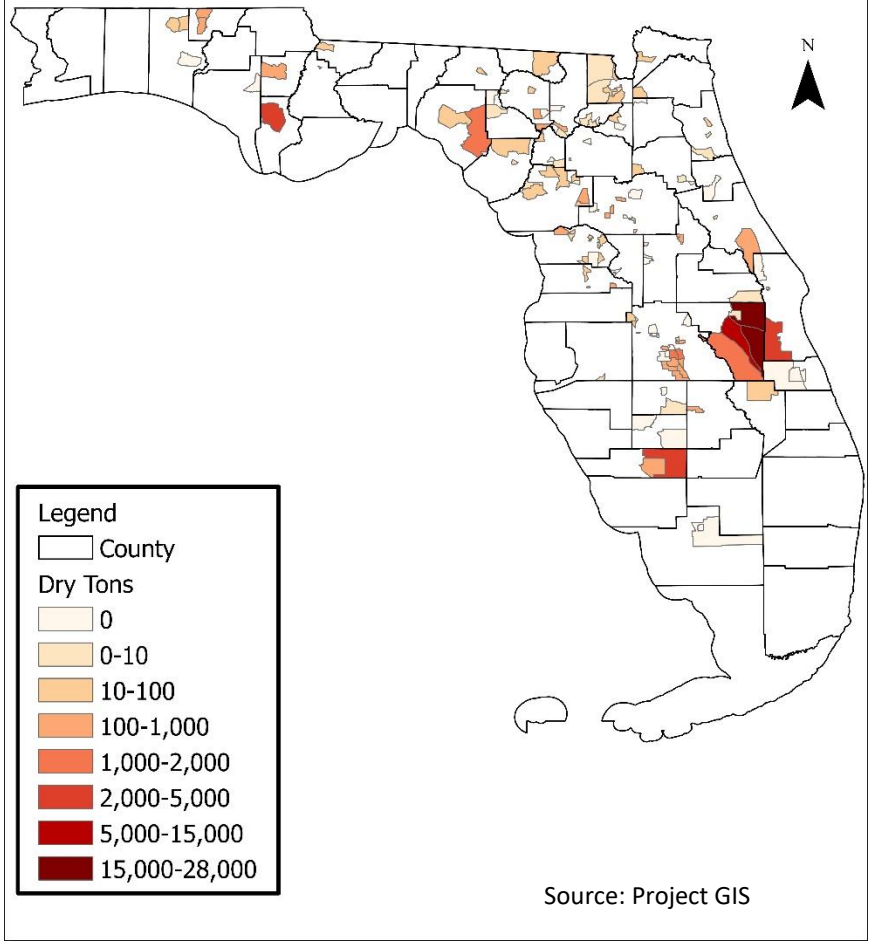
VARIABLES	(1) Median Income	(2) Percent Non-white	(3) Population Density (E3)	(4) Improved Pasture
Send Only	4,205	5.898	0.322*	-18,955
	(3,735)	(4.357)	(0.189)	(21,959)
Receive Only	-914.2	1.712	-0.171	68,782**
	(4,524)	(5.276)	(0.229)	(26,594)
Constant	52,417***	29.45***	0.405***	47,877***
	(1,599)	(1.865)	(0.0811)	(9,402)
Observations	67	67	67	67
R-squared	0.022	0.028	0.058	0.115

Notes: Standard errors are in parentheses; significant variation from the control is shown by asterisks: *** p<0.01, ** p<0.05, * p<0.1

The above results are intuitively plausible: high density counties are exporting biosolids to counties with large areas of improved pasture to accommodate them. Table 6 shows that both exporting and importing county groups are larger on average than the control group, but not in a statistically significant amount.

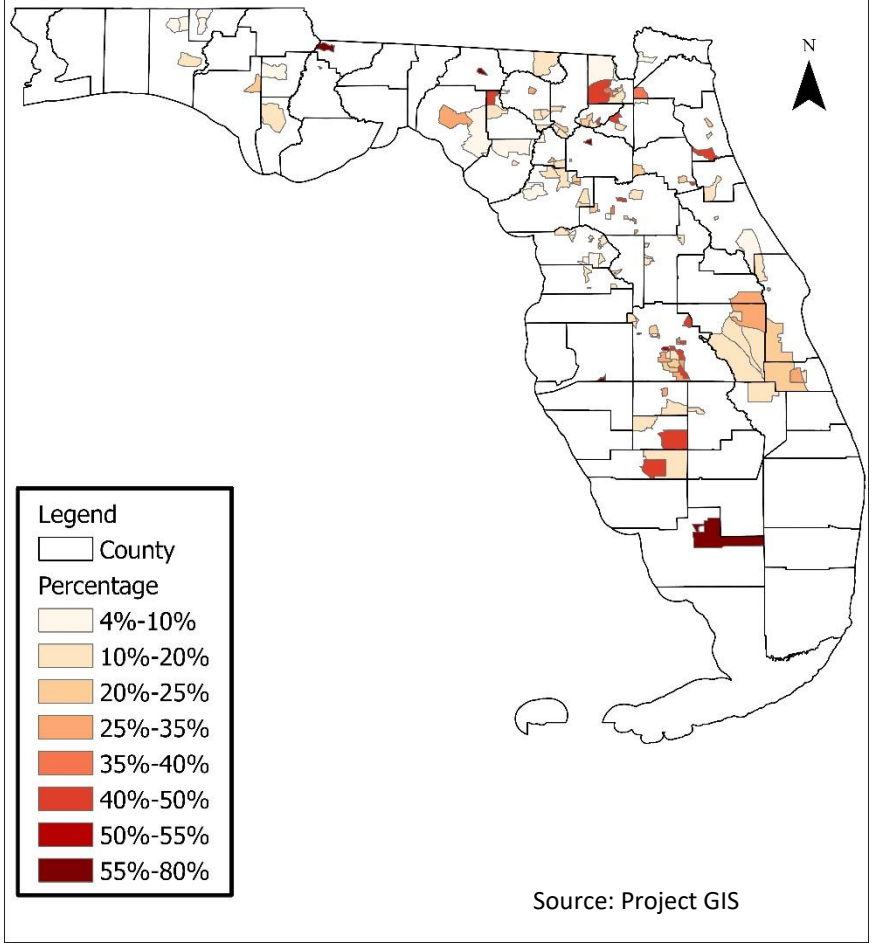
The following maps describe the demographics of block groups receiving Class B biosolids. Each is accompanied by a map providing the annual quantity of Class B biosolids being applied. At a state-wide level of presentation, the Census block groups are too small to visualize differences as overlays between the demographic parameters and the base layer of biosolids application.

Census Block Group Reference:
Annual Land Application of Class B Biosolids (2019-2021)



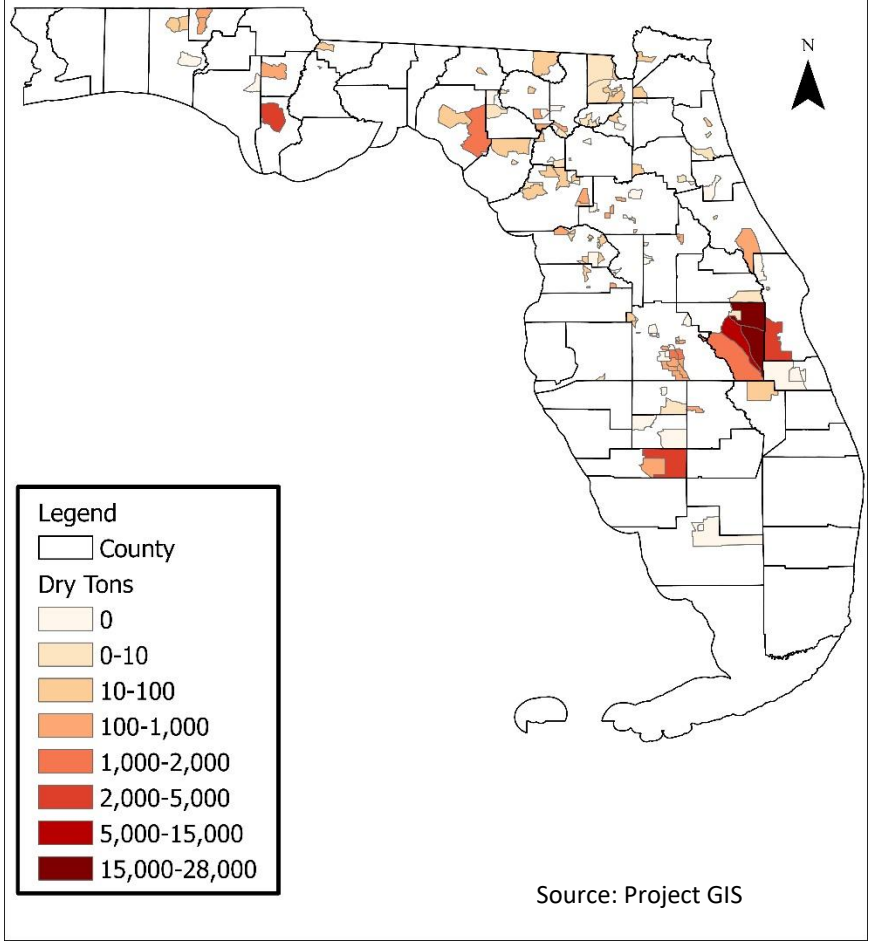
Source: Project GIS

Percent Non-White Population, by Block Group



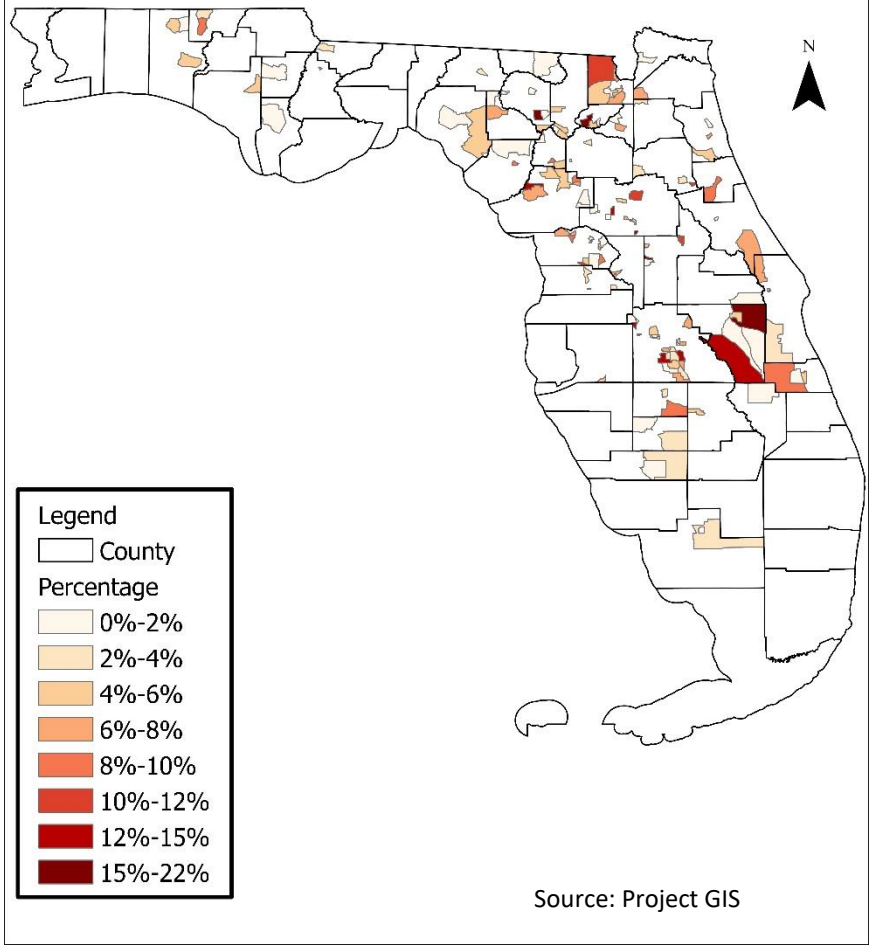
Source: Project GIS

Block Group Reference:
Annual Land Application of Class B Biosolids (2019-2021)



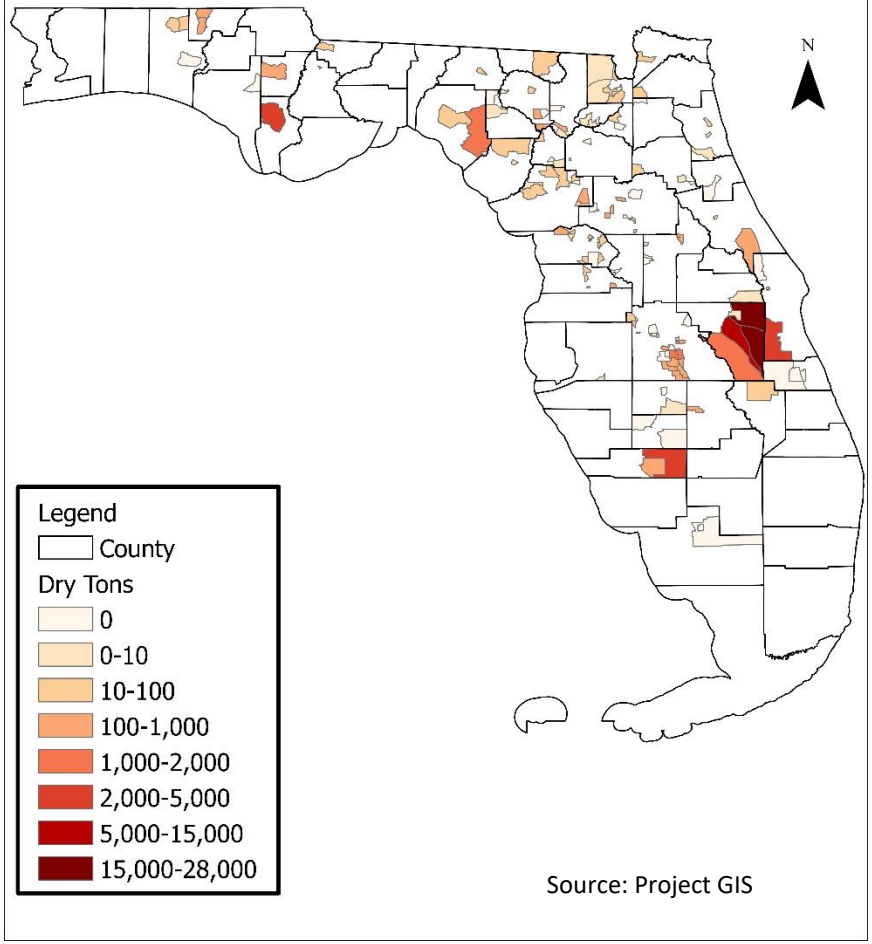
Source: Project GIS

Percent Under Age 5, by Block Group



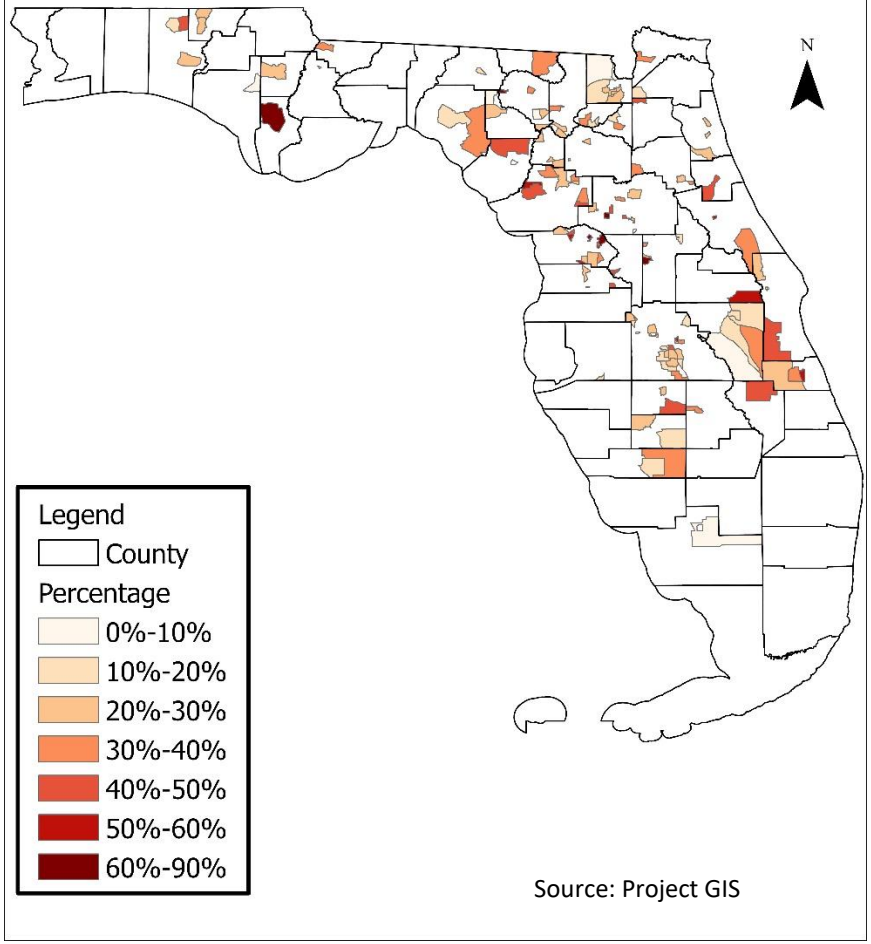
Source: Project GIS

Block Group Reference:
Annual Land Application of Class B Biosolids (2019-2021)



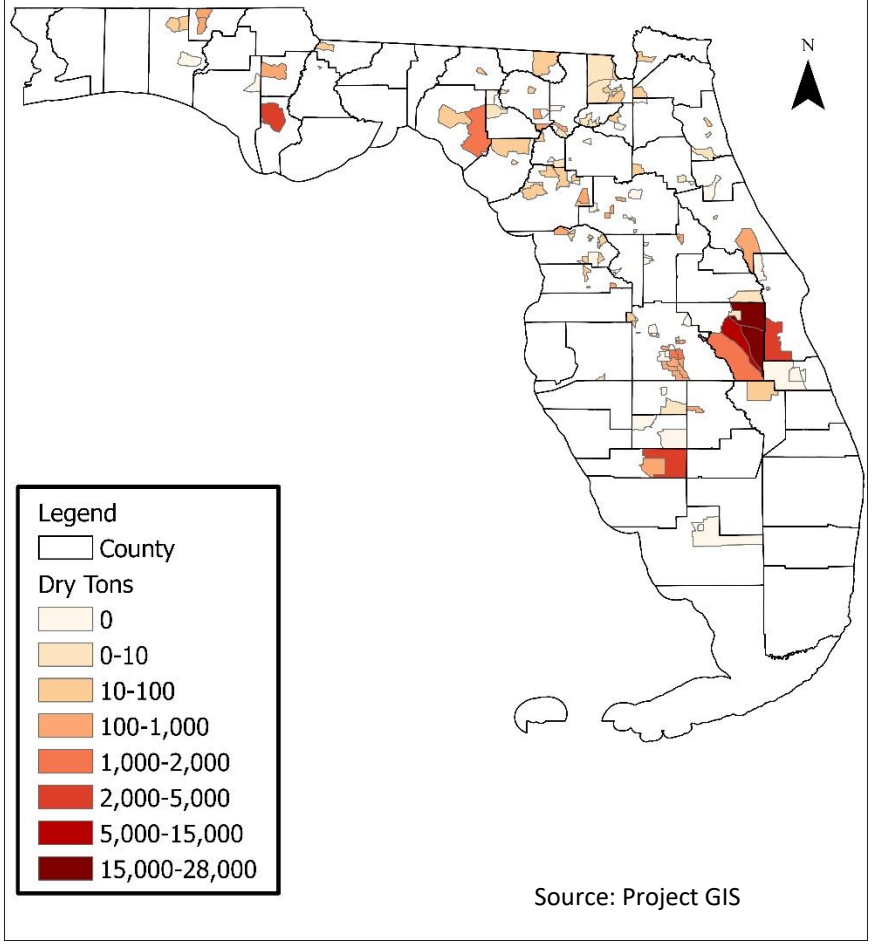
Source: Project GIS

Percent Over Age 60, By Block Group



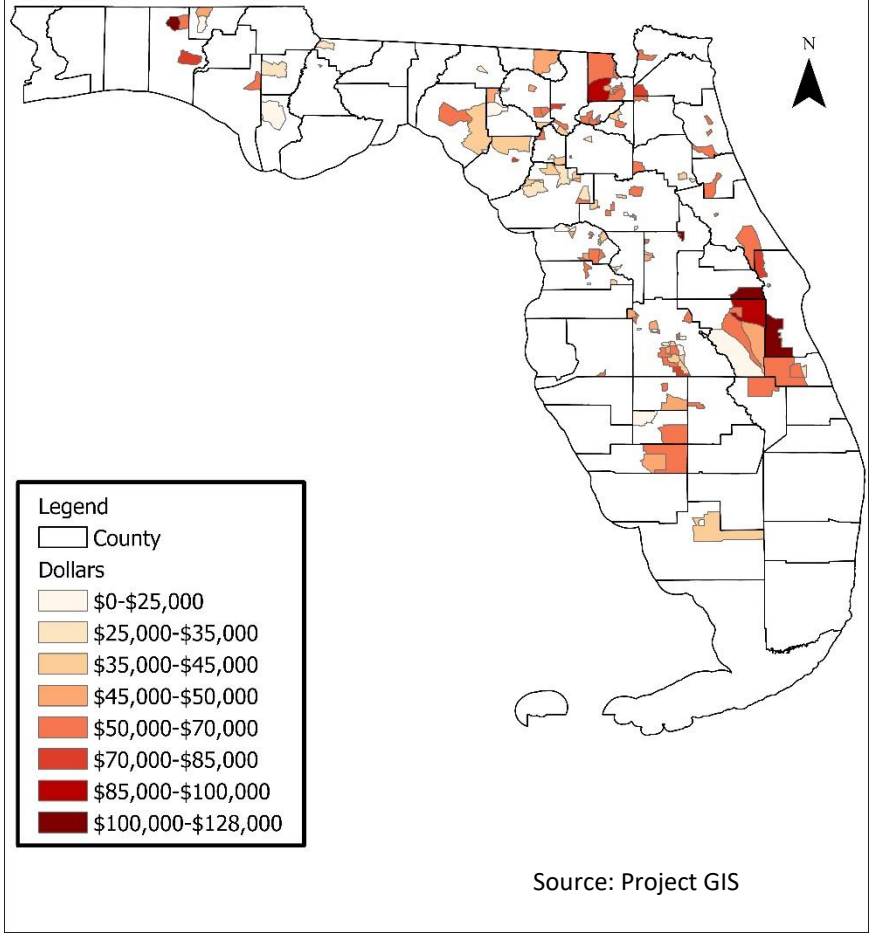
Source: Project GIS

Block Group Reference:
Annual Land Application of Class B Biosolids (2019-2021)



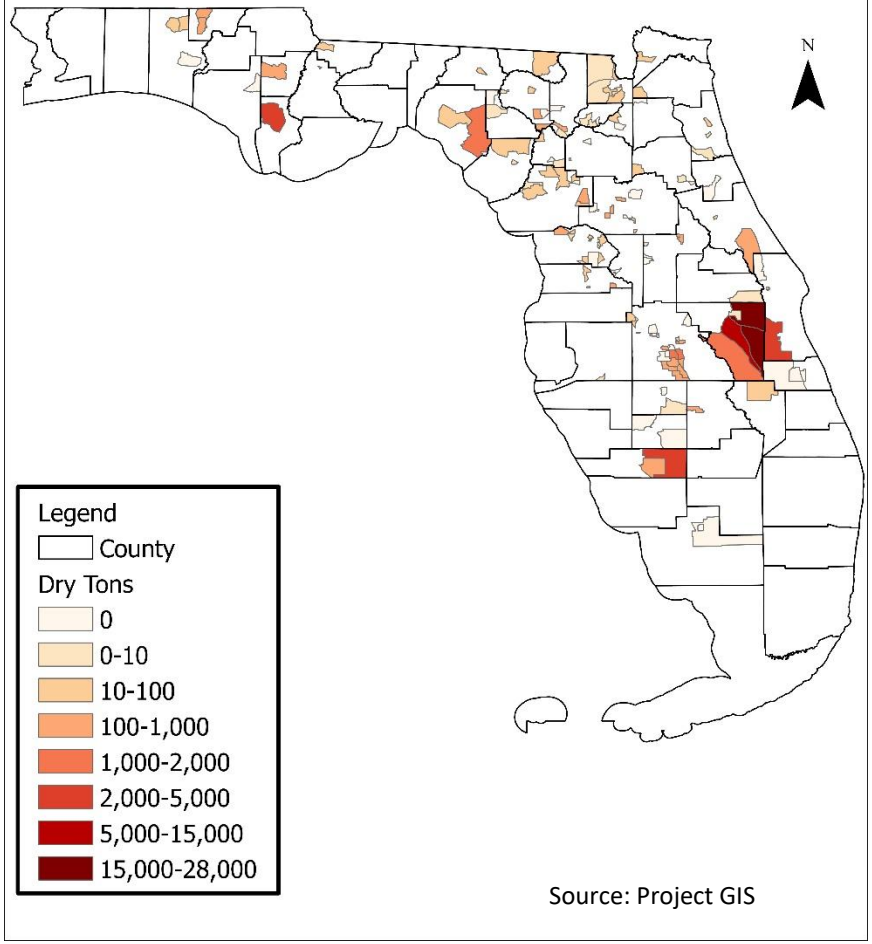
Source: Project GIS

Median Household Income, by Block Group



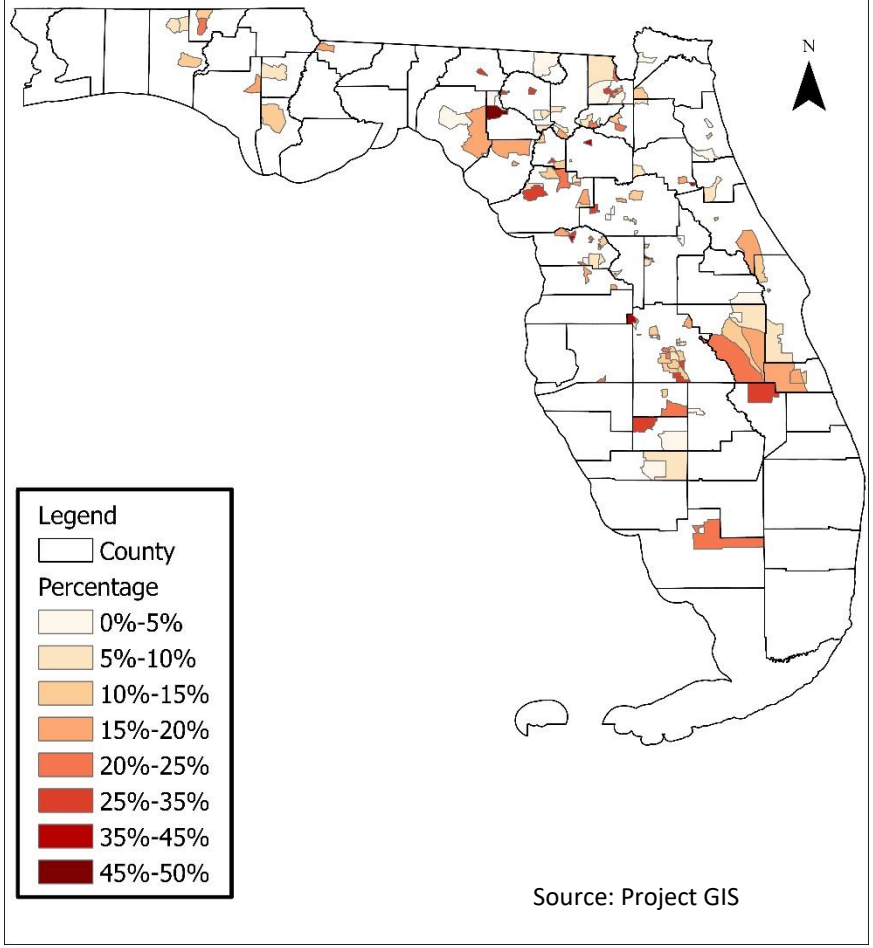
Source: Project GIS

Block Group Reference:
Annual Land Application of Class B Biosolids (2019-2021)



Source: Project GIS

Percent Below Poverty Level, by Block Group



Source: Project GIS

- HUC12 Watershed Application site facility presence shows a statistically significant relationship with Block Group Total Population (+), Percent Non-White Population (-), Median Household Income (-), and Percent Over 60 Population (+).
- Considering Watershed and Land Cover characteristics, HUC12 Watershed application site facility presence shows a statistically significant relationship with Block Group Percent Non-White Population (-), Median Household Income (-), and Percent Over 60 Population (+).
- HUC12 Watershed application site area shows a statistically significant relationship with Block Group Total Population (+), Percent Non-White Population (-) and Median Household Income (+).
- Considering Watershed and Land Cover characteristics, HUC12 Watershed application site area shows a statistically significant relationship with Block Group Total Population (+), Median Household Income (+), Percent Under 5 Population (+), and Percent Over 60 Population (-).
- HUC12 Watershed application site Class B Quantities show a statistically significant relationship with Block Group Total Population (+), Percent Non-White Population (-), Median Household Income (+), and Percent Under 5 Population (+).
- Considering Watershed and Land Cover characteristics, HUC12 Watershed application quantities show a statistically significant relationship with Block Group Total Population (+), Median Household Income (+), Percent Under 5 Population (+), and Percent Over 60 Population (-)
- Looking only at watersheds with an application site, HUC12 Watershed application site area shows a statistically significant relationship with Block Group Total Population (+), Median Household Income (+), Percent Under 5 Population (+), and percent Over 60 Population (-).
- Looking only at watersheds with an application site and considering Watershed and Land Cover characteristics, HUC12 Watershed application site area shows a statistically significant relationship with Block Group Total Population (+) and Median Household Income (+).
- Looking only at watersheds with an application site, HUC12 Watershed application site quantities show a statistically significant relationship with Block Group Total Population (+), Median Household Income (+), Percent Under 5 Population (+), and Percent Over 60 Population (-).
- Looking only at watersheds with an application site and considering Watershed and Land Cover characteristics, HUC12 Watershed application site quantities show a statistically significant relationship with Block Group Total Population (+) and Median Household Income (+)

Appendix E. Watershed and Land Cover Statistical Output

Basic statistical parameters for hydrologic and land cover data – minimum, maximum and average -- for Block Groups, statewide (State) and within subwatersheds containing application sites (Applied HUC12).

- Slope (Percent of Distance)
  - State min, max, avg. = 0, 13.30, 1.98
  - Applied HUC12 min, max, average = 0.65, 7.64, 1.85
- WTD (depth to seasonal water table, cm)
  - State min, max, avg. = 0, 118.60, 29.67
  - Applied HUC12 min, max, average = 5.01, 118.60, 29.46
- Flood Frequency (Dominant)
  - State min, max, avg. = 0, 5.02, 1.25
  - Applied HUC12 min, max, average = 0.89, 1.87, 1.11
- Flooding Frequency (Maximum)
  - State min, max, avg. = 0, 5.02, 1.28
  - Applied HUC12 min, max, average = 0.89, 1.86, 1.13
- Drainage (Dominant)
  - State min, max, avg. = 0, 7, 2.49
  - Applied HUC12 min, max, average = 1.23, 5.13, 2.49
- Drainage (Wettest)
  - State min, max, avg. = 0, 7, 2.46
  - Applied HUC12 min, max, average = 1.23, 4.84, 2.46
- IP (Improved Pasture, Sq Mi)
  - State min, max, avg. = 0, 128.63, 6.81
  - Applied HUC12 min, max, average = 0, 107.97, 16.51
- CP (Cropland Pasture, Sq Mi)
  - State min, max, avg. = 0, 27.87, 1.72
  - Applied HUC12 min, max, average = 0, 27.87, 2.31
- HIU (High Intensity Urban, Sq Mi)
  - State min, max, avg. = 0, 58.01, 2.94
  - Applied HUC12 min, max, average = 0, 32.88, 1.99
- LIU (Low Intensity Urban, Sq Mi)
  - State min, max, avg. = 0, 30.42, 1.66
  - Applied HUC12 min, max, average = 0, 30.42, 2.44
- OA (Other Agriculture, Sq Mi)
  - State min, max, avg. = 0, 44.31, 0.19
  - Applied HUC12 min, max, average = 0, 44.31, 0.84
- RU (Rural, Sq Mi)
  - State min, max, avg. = 0, 21.16, 2.12
  - Applied HUC12 min, max, average = 0.19, 16.30, 3.19

For the following models, the sign (+ or -) describes the relationship identified with the variable.

Watershed and Land Cover characteristics influencing Block Group Population across the state,

- Slope (-), WTD (-), Drainage (dominant (-) & wettest (+)), CP (-), HIU (-), LIU (+), OA (-), RU (+)

Watershed and Land Cover characteristics influencing Block Group Percent Non-White Population across the state

- Slope (+), WTD (+), Flood (dominant (-)), Drainage (dominant (-), wettest (+)), IP (-), CP (-), HIU (+), LIU (-), OA (+), RU (+)

Watershed and Land Cover characteristics influencing Block Group Median Household Income across the state

- Slope (-), Flood (dominant (-), max (+)), Drainage (dominant (+), wettest (-)), IP (-), CP (+), HIU (+), LIU (+), OA (-), RU (-)

Watershed and Land Cover characteristics influencing Block Group Percent Under 5 Population across the state

- WTD (+), Flood (dominant (-), max (+), Drainage (dominant (-), wettest (+)), CP (-), HIU (+), LIU (-), RU (+)

Watershed and Land Cover characteristics influencing Block Group Percent Over 60 Population across the state

- Slope (-), WTD (-), Flood (dominant (+)), Drainage (dominant (+), wettest (-)), IP (+), CP (+), HIU (-), LIU (+), OA (-), RU (-)

Watershed and Land Cover characteristics influencing Block Group Population across HUC12 Watersheds with an application site

- Slope (-), WTD (-), Flood (dominant (-), Max (+)), Drainage (dominant (-), wettest (+)), RU (+)

Watershed and Land Cover characteristics influencing Block Group Percent Non-White Population across HUC12 Watersheds with an application site

- Slope (+), WTD (+), Flood (max (-)), IP (-), HIU (+)

Watershed and Land Cover characteristics influencing Block Group Median Household Income across HUC12 Watersheds with an application site

- WTD (-), Drainage (dominant (-), wettest (+)), LIU (-), RU (+)

Watershed and Land Cover characteristics influencing Block Group Percent Under 5 Population across HUC12 Watersheds with an application site

- WTD (+), IP (+), HIU (+), OA (-), RU (+)

Watershed and Land Cover characteristics influencing Block Group Percent Over 60 Population across HUC12 Watersheds with an application site

- WTD (-), Drainage (wettest (+)

Total Nitrogen and Total Phosphorus (TNTP) Logistic Regression Results

Application & Impairment

Coefficient of Index = 0.0004922

Log odds of a waterbody being impaired increases by 0.0004922 for every one-unit increase in the Application

Intercept = -1.920279 = log odds when no biosolids are applied

P-Value = 0.002 (Statistically Significant)

Odds Ratio [exp(0.0004922) = 1.0004927]

Odds of Impairment increase by ~0.04927% for every one-unit increase in Application

LR Chi-Square (1) = 11.48, P-value = 0.0007

Model as a whole is Statistically Significant

Psuedo R-Squared = 0.0658

```
. logit Impairment H12_AS_19_21_AVG_APP

Iteration 0:  Log likelihood =  -87.22883
Iteration 1:  Log likelihood = -82.303995
Iteration 2:  Log likelihood = -81.516327
Iteration 3:  Log likelihood = -81.486788
Iteration 4:  Log likelihood = -81.486766
Iteration 5:  Log likelihood = -81.486766

Logistic regression                                     Number of obs =    196
                                                        LR chi2(1)    =  11.48
                                                        Prob > chi2   = 0.0007
Log likelihood = -81.486766                             Pseudo R2     = 0.0658
```

Impairment	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
H12_AS_19_21_AVG_APP	.0004922	.0001557	3.16	0.002	.000187	.0007973
_cons	-1.920279	.2242905	-8.56	0.000	-2.359881	-1.480678

Distance & Impairment

Coefficient of Distance = 0.0143979

P-Value = 0.949 (Not Statistically Significant)

Odds Ratio [exp(0.0143979) = 1.0145]

Odds of Impairment increase by ~1.45% for every one-unit increase in distance

Intercept = -1.653104 = log odds when distance is zero

LR Chi-Square (1) = 0.00, P-value = 0.9491

Model as a whole is Not Statistically Significant

Pseudo R-Squared = 0.0000

Model does not explain much of the variance in the dependent variable (Impairment)

```
. logit Impairment Distance

Iteration 0:  Log likelihood =  -87.22883
Iteration 1:  Log likelihood =  -87.22679
Iteration 2:  Log likelihood =  -87.22679

Logistic regression                                     Number of obs =    196
                                                        LR chi2(1)    =   0.00
                                                        Prob > chi2   = 0.9491
Log likelihood = -87.22679                              Pseudo R2     = 0.0000

------------------------------------------------------------------------------
  Impairment | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
    Distance |   .0143979    .225031     0.06   0.949    -.4266549    .4554506
       _cons |  -1.653104   .3546349    -4.66   0.000    -2.348176   -.9580328
------------------------------------------------------------------------------
```

Application/Distance & Impairment

Odds ratio of Application = 1.000513

Odds of Impairment increase by a Factor of ~1.0005 (0.05%)

P-Value = 0.001 (Statistically Significant)

Odds ratio of Distance = 1.171335

P-value = 0.497 (Not Statistically Significant)

LR Chi-Square (2) = 11.93, P-value = 0.0026

Model as a whole is Statistically Significant

Pseudo R-Square = 0.0684

Model explains 6.84% of variance

```
. logistic Impairment H12_AS_19_21_AVG_APP Distance

Logistic regression                                     Number of obs =    196
                                                        LR chi2(2)    =  11.93
                                                        Prob > chi2   = 0.0026
Log likelihood = -81.263678                             Pseudo R2     = 0.0684

------------------------------------------------------------------------------
  Impairment | Odds ratio   Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
H12_AS_19_21~P |   1.000513   .000161     3.19   0.001     1.000198    1.000829
    Distance |   1.171335   .2727039     0.68   0.497     .7421798    1.848644
       _cons |   .1174159   .0475611    -5.29   0.000     .0530805    .2597281
------------------------------------------------------------------------------
Note: _cons estimates baseline odds.
```

Index & Impairment

Coefficient of Index = 0.0002345

Log odds of a waterbody being impaired increases by 0.0002345 for every one-unit increase in the Index

P-value = 0.015 (Statistically Significant)

Odds Ratio [exp(0.0002345) = 1.0002347]

Odds of impairment increase by ~0.02347%

LR Chi-Square (1) = 8.13, P-value = 0.0044

Model as a whole is statistically significant

Psuedo R2 = 0.0466

Model explains approximately 4.66% of the variance in the likelihood of impairment

```
. logit Impairment Index

Iteration 0:  Log likelihood =  -87.22883
Iteration 1:  Log likelihood = -83.419911
Iteration 2:  Log likelihood = -83.166678
Iteration 3:  Log likelihood = -83.164327
Iteration 4:  Log likelihood = -83.164327

Logistic regression                                     Number of obs =    196
                                                        LR chi2(1)    =   8.13
                                                        Prob > chi2   = 0.0044
Log likelihood = -83.164327                             Pseudo R2     = 0.0466

------------------------------------------------------------------------------
  Impairment | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
       Index |   .0002345   .0000961     2.44   0.015     .0000461    .0004229
       _cons |   -1.82788   .2147686    -8.51   0.000    -2.248819   -1.406941
------------------------------------------------------------------------------
```

Land Cover

By looking at land cover across watersheds, we can get a better idea of what is influencing groundwater. The results show that Tree Plantations (14% UA, 19% CA), followed by Improved Pasture (13% UA, 12% CA), are the dominant land cover types in applied watersheds and watersheds that adjoin all applied watersheds. Looking only at applied watersheds, Tree Plantations (16% UA, 17% CA) and Improved Pasture (16% UA, 13% CA) are still the dominant land cover types. Adjoining watersheds not applied with biosolids also have Tree Plantations (13% UA, 20% CA) and Improved Pasture (12% UA, 12% CA) as the dominant land cover type.

Overall, applied watersheds have a higher percentage of Tree Plantations and Improved Pasture land cover types in watersheds measuring unconfined aquifers. Non-applied watersheds have a higher percentage of Tree Plantations and about the same percentage of Improved Pasture in watersheds measuring confined aquifers. Based on these results, we should expect to see higher levels of nutrients in applied watersheds for unconfined aquifers and non-applied watersheds for confined aquifers, but groundwater data is showing the opposite.

If we look more closely at land cover, we can see that there is a greater percentage of Other Agriculture (4.44%), High Intensity Urban (5.06%), and Low Intensity Urban (6.67%) in applied watersheds compared to adjoining watersheds for confined aquifers (0.68%, 2.34%, and 2.96%, respectively). These may be contributing to higher levels of nutrients in applied watersheds when measuring confined aquifers.

On the other hand, there is a greater percentage of Cropland/Pasture (6.58%), Other Agriculture (5.01%), Rural (8.01%), High Intensity Urban (5.21%), and Low Intensity Urban (6.45%) land cover types in applied watersheds compared to adjoining watersheds for unconfined aquifers (4.87%, 0.38%, 6.90%, 6.43%, and 4.61%, respectively). High Intensity Urban is the only land cover type that has a greater percentage in non-applied watersheds compared to applied watersheds, but is a land cover type that can contribute high levels of nutrients to groundwater through stormwater runoff.

Total Area	Land Cover	Sq. Mi.	% of Total
1074.772	Tree Plantations	167.76	15.61
	Improved Pasture	170.83	15.89
	Cropland/Pasture	70.70	6.58
	Other Agriculture	53.82	5.01
	Rural	86.05	8.01
	High Intensity Urban	56.02	5.21
	Low Intensity Urban	69.32	6.45

UA Applied

Total Area	Land Cover	Sq. Mi.	% of Total
2241.548	Tree Plantations	297.37	13.27
	Improved Pasture	273.58	12.20
	Cropland/Pasture	109.20	4.87
	Other Agriculture	8.52	0.38
	Rural	154.59	6.90
	High Intensity Urban	144.09	6.43
	Low Intensity Urban	103.30	4.61

UA Not Applied

Total Area	Land Cover	Sq. Mi.	% of Total
1553.553	Tree Plantations	270.85	17.43
	Improved Pasture	202.16	13.01
	Cropland/Pasture	82.70	5.32
	Other Agriculture	68.98	4.44
	Rural	98.24	6.32
	High Intensity Urban	78.56	5.06
	Low Intensity Urban	103.64	6.67

CA Applied

Total Area	Land Cover	Sq. Mi.	% of Total
1953.477	Tree Plantations	399.19	20.43
	Improved Pasture	227.44	11.64
	Cropland/Pasture	79.15	4.05
	Other Agriculture	13.34	0.68
	Rural	129.03	6.61
	High Intensity Urban	45.62	2.34
	Low Intensity Urban	57.84	2.96

CA Not Applied

Appendix F. Estimated Runoff of Labile Nutrients from Biosolids

There is no single, definitive study of the runoff of nutrients (nitrogen and phosphorus) from biosolids across the Florida landscape. Large ranges of values occur (greater than one order of magnitude) throughout the applicable literature, both in-state and out-of-state (with emphasis on grazing lands).

A means is needed to translate the coarse application of nutrients into quantities of labile material that may pass into receiving waters. One approach is to estimate the percentage of residual labile material in the soil prior to lateral transport by considering several factors: plant uptake, volatilization of urea to gaseous nitrogen (N2), conversion of nitrate to N2, and expected plant uptake.

I. While some global-level estimates are higher, agronomic literature (including that for Florida) values suggest as much as 60% of applied nitrogen in lost. This is a generalized number not inconsistent with an average of 30% due to volatilization (with ranges of less than 1% to a maximum of 60%, depending on site conditions and temperature), an average of 25% due to denitrification (with ranges of 10% to 40%), and the estimate of 1.6% due to leaching to groundwater (see Appendix G). Plant uptake rates in turn range from 30% to 50% of the applied amounts.

   Summing the above average pathway values yields 95% of applied nitrogen being accounted for, with approximately *3.4% lost via runoff and 1.6% lost via leaching*, which in turn may flow towards surface waters. Only if it is assumed that less-than-average values for volatilization and denitrification are applicable on Florida improved pasture would rates of export via surface waters be meaningfully greater.

II. Alternatively, one could consider the use of a runoff coefficient. Runoff carries the share of remaining, unconverted and unassimilated nitrogen. SJRWMD hydrological standards include an average coefficient of 0.175 for pastures with sandy soils and 0.225 for clay soils (0%-2% grades). The average runoff coefficient for typical Central Florida pastureland would then be 0.20. Assuming lower than average values of volatilization (e.g., 20%), denitrification (20%), and uptake (30%) would result in approximately 30% of applied nitrogen available for export. *With a coefficient of 0.20, the export of nitrogen via direct runoff should be 6% of the total applied*.[1]

- The two above methods, relying on average versus less-than-average values for nitrogen conversion processes, yield similar results. **For purposes of this study an average of 5.5% is assumed to address runoff and leaching jointly (see Appendix G).**

[1] Numerous reports (including Roderick, 2019) have suggested that 12% is a conservative estimate of land applied nutrients (TN and TP, whether as fertilizer or as biosolids) being discharged to surface waters via stormwater runoff. It is possible that this percentage (or higher) occurs in some watersheds at select times of the year (e.g., especially following major storms), but may not account for actual the timing of applications, BMPs, uptake and export, denitrification, adsorption, etc.

Appendix G. Estimated Leaching of Labile Nutrients from Biosolids

There is no single, definitive study of the leaching of nutrients (nitrogen and phosphorus) from biosolids across the Florida landscape. Large ranges of values occur (greater than one order of magnitude) throughout the applicable literature, both in-state and out-of-state (with emphasis on grazing lands).

Additional challenges lie in what is measured and how the data are reported. For example, IFAS has performed detailed assessments of several landscapes (pasture, forests, row crops, etc.) using lysimeters to quantify leaching and the data are reported in parts per million (ppm, mg/l) with no corresponding information regarding the volumes of water collected or measured over what duration (other than at a "seasonal" level). Further, data are reported in some reports in terms of Total Nitrogen (TN) and Total Phosphorus (TP), failing to recognize organic and mineralized fractions that do not result in typical, immediate enhancement of gross primary productivity in the water column (i.e., algal blooms). The share of labile phosphorus in particular is affected by adsorption and macro-aggregation.[1] However, depending on soil capacity ("soil P storage capacity"), water soluble phosphorus may be released.[2]

A means is needed to translate the coarse application of nutrients into quantities of labile material that may pass into receiving waters. One approach is to estimate the percentage of labile material by dividing typical applied quantities of nutrients in Class B biosolids (as a percentage of mass) by (published) leaching rates (as mass per unit area over time).

Nitrogen: From within this study the total area of Class B application sites is 101,376 acres (41,027 hectares). Prior estimates of Class B applications have been approximately 110,000 dry tons.[3] An accepted percentage for Total Nitrogen is 5.5%.

*(110,000 tons/yr) * (2000 lb/ton) / (101,376 ac) * 5.5% TN = 119.38 lb N/ac-yr*

One grazing land leaching rate providing the rate of nitrate was 2.1 kg NO3/ha-yr

*(2.1 kg NO3/ha-yr) *(2.205 lb/kg) * (1 ha/2.471 ac) = 1.874 lb NO3/ac-yr*

(1.874 lb N/ac-yr) / (119.38 lb N/ac-yr) = 1.57% (lb NO3/ lb TN)

- The value of 1.57% should be applicable to the estimates of total nitrogen in biosolids to estimate the quantity of nitrate leached into nearby soils and ground waters.

[1] https://passel2.unl.edu/view/lesson/069083583880/5#:~:text=total%20soil%20P.-,Labile%20P,the%20soluble%20phase%20relatively%20quickly.

[2] Nair, V. 2010. Understanding Soil Phosphorus Storage Capacity, IFAS, Publication SL336

[3] Roderick, 2019. Biosolids transfers total 83,969 annually between 2019 and 2021 but do not capture all within-county application or amounts from producers not reporting to the EPA.

Phosphorus: From within this study the total area of Class B application sites is 101,376 acres (41,027 hectares). Prior estimates of Class B applications have been approximately 110,000 dry tons (above reference). A broadly accepted percentage for Total Phosphorus in biosolids is 2.2%.

(110,000 tons/yr) / 41,027 ha = 2.681 ton/ha-yr
*(2.681 ton/ha) * (2000 lb/ton) = 5,362 lb/ha-yr*
*(5,362 lb/ha) * (0.022 lb TN/lb) = 118.0 lb TP/ha-yr*
*(118.0 lb TP/ha) * (0.454 kg/lb) = 53.6 kg TP/ha-yr*

Capece reports summer leaching rates of 1.71 kg PO4/ha and winter rates of 0.25 kg PO4/ha. The annual total is 1.96 kg PO4/ha-yr

(1.96 kg PO4/ha-yr) / (53.6 kg TP/ha-yr) = 3.66% (PO4/TP)

- The value of 3.66% should be applicable to the estimates of total phosphorus in biosolids to estimate the quantity leached into nearby soils and surface waters.

Class AA: The above estimates are for Class B biosolids only. Composted products (i.e., Class AA or Aeq) have been shown to have significantly smaller percentages of release. For example, due to the biological processes of composting, nutrients are incorporated into organic compounds that are resistant to degradation. Approximately 10% of the nitrogen in these organic compounds will become available through mineralization in the first growing season. Some nitrogen will become available in subsequent years, but at a slower rate than the first year.

The critical consideration is that not all nitrogen in biosolids is in a mineralized form upon deposition (land application). Highly composted products may contain 10% the nitrogen of biosolids (at 0.5% rather than greater than 5.0%) and of that amount a smaller percentage will be labile.[4] The difference in available nitrogen between highly composted product and Class B is on the order of 0.05% (0.5%*10%) versus 1.65% (5.5%*30%), a factor of one-thirty-fifth.

Unlike chemically-based fertilizers, phosphorus is not readily extracted from composted materials. As with nitrogen, much of the phosphorus in finished compost is incorporated into organic matter. Further, not all of the phosphorus subsequently mineralized from organic matter is available for crop uptake because a portion of the released phosphorus may be made unavailable by binding with other elements in the soil (Fe, Al, and Ca).

[4] The USEPA estimated first year mineralizable N coefficients to be 30% for aerobically digested biosolids, 20% for anaerobically digested, and 10% for composted. These estimates accounted for stabilization methods, soil type, and climate (Antille et al., 2013; Correa et al., 2006, 2012; Paula et al., 2011; Yoshida et al 2015).

Appendix H. Cost Benefit Analysis

Landfilling

Biosolids Benefit:Cost Analysis

Alt. #1: Conventional Wastewater Treatment Facility & Local Landfilling of Class B Biosolids (per additional increment of 1000 Dry Tons per year)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0	$0	$0	$0	$0	Existing Facility; No additional land costs assumed
Design & Permitting Costs	per system	0	$0	$0	$0	$0	Existing Facility; No additional system costs assumed
System Purchase (CAPEX)	per system	0	$0	$0	$0	$0	Existing Facility; No additional capital costs assumed
O&M / Repair (OPEX)	mile / year	7,500	$12,681	$120,297	$103,456	$89,915	Existing Facility; No additional O&M costs assumed for Landfill; O&M costs for local hauler
Replacement (Life-Cycle)	per year	0.07	$10,683	$101,340	$87,153	$75,746	Based on 15-year lifespan; transport equipment only
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade County for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	1,000	$57,766	$547,970	$471,257	$409,575	State Average (includes tipping fee)
Transport of Biosolids	per ton	1,000	$37,848	$359,027	$308,765	$268,351	Based on DEP state-level estimates, adjusted to local
Spreading of Biosolids	per ton	0	$0	$0	$0	$0	Not Applicable, Landfill only
Direct Cost Sub-Total				$3,440,100	$2,958,506	$2,571,272	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	0	$0	$0	$0	$0	Odor, Public Perception; No incremental cost for existing site
Public Health Impacts	HH	0	$0	$0	$0	$0	No incremental cost for existing site
Loss of Nutrient Input to Agriculture	$/lb	1,000	$36,520	$346,432	$297,934	$258,938	Combined Market Value of UAN28 and DAP is $36.52 per ton at biosolids concentrations
Loss of Landfill Capacity	per ton	1,000	$33,441	$317,221	$272,812	$237,104	Cost of incremental capacity
Indirect Cost Sub-Total				$663,653	$570,745	$496,042	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of local transport
GHGs from Landfilled Biosolids	kg / ton	1,000	$216,041	$2,049,383	$1,762,481	$1,531,793	America Chemical Society life-cycle costs of waste; CO2 and Methane
GHGs from Land-Applied Biosolids	kg	-	$0	$0	$0	$0	None land applied
Well Contamination	HH / yr	-	$0	$0	$0	$0	None land applied; Leachate Collection Assumed
Shadow Price of Nutrient Pollution (N)	lb / yr	-	$0	$0	$0	$0	None land applied; Leachate Collection Assumed
Shadow Price of Nutrient Pollution (P)	lb / yr	-	$0	$0	$0	$0	None land applied; Leachate Collection Assumed
Non-Market Cost Sub-Total				$2,120,089	$1,823,289	$1,584,642	
Total Costs				$6,223,842	$5,352,540	$4,651,955	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	-	$0	$0	$0	$0	None Recovered
Recovered Phosphorus	kg / 1E3 ton	-	$0	$0	$0	$0	None Recovered
Electric Revenues	kwh / 1E3 ton	-	$0	$0	$0	$0	None Recovered
Compost Revenues	per ton		$0	$0	$0	$0	Not Applicable
Avoided Costs for Fertilizer	per ac	-	$0	$0	$0	$0	Not Applicable
Avoided Treatment Costs - N	lb-N / yr	110,000	$202,335	$1,919,373	$1,650,672	$1,434,618	Per DEP Stormwater Project Costs per lb; 5.5% nitrogen
Avoided Treatment Costs - P	lb-P / yr	44,000	$145,200	$1,377,382	$1,184,556	$1,029,512	Per DEP Stormwater Project Costs per lb; 2.2% phosphorus
Avoided Landfill Costs	per ton	0	$0	$0	$0	$0	Miami Dade, value of landfill capacity
Residual Value	per system	-	$0	$0	$0	$0	Not Applicable
Direct Benefits Sub-Total				$3,296,755	$2,835,228	$2,464,129	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	per HH		$0	$0	$0	$0	Addressed by Avoided Treatment Costs
Community values (aesthetics, recreation & tourism)	per person	-	$0	$0	$0	$0	Included in WTP
Non-Market Benefits Sub-Total				$0	$0	$0	
Total Benefits				$3,296,755	$2,835,228	$2,464,129	

Results			
Net Benefits	($2,927,088)	($2,517,312)	($2,187,825)
Benefit:Cost Ratio	0.530	0.530	0.530

Appendix H. Benefit Cost Analysis (Continued)

Land Application

Biosolids Benefit:Cost Analysis

Alt. #2: Conventional Wastewater Treatment Facility & Land Application of Class B Biosolids (per additional increment of 1000 Dry Tons per year)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0	$0	$0	$0	$0	Existing Facility; No additional land costs assumed
Design & Permitting Costs	per system	1	$15,000	$15,000	$15,000	$15,000	Per DEP schedule, for Type I facilities $7500 for design review and $7500 for permit application; however, DEP SERC indicated $200/ac for permits
System Purchase (CAPEX)	per system	1	$46,643	$46,643	$46,643	$46,643	Costs for manure spreader and storage shed
O&M / Repair (OPEX)	mile / year	15,444	$26,114	$247,715	$213,037	$185,153	O&M costs for long-distance hauler and for application site spreader
Replacement (Life-Cycle)	per year	0.08	$26,990	$256,031	$220,188	$191,368	Based on 12-year lifespan, long-haul transport equipment; spreader (3 years) and shed (5 years)
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	0	$0	$0	$0	$0	Not Applicable, Land Apply only
Transport of Biosolids	per ton	1,000	$246,010	$2,333,674	$2,006,973	$1,744,284	Based on DEP SERC, 195 miles one-way
Spreading of Biosolids	per ton	851	$6,517	$61,819	$53,165	$46,206	Based on DEP and farm reported costs for operating spreaders per acre
Direct Cost Sub-Total				$5,272,349	$4,542,880	$3,956,338	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	20	$415,378	$3,940,313	$3,388,692	$2,945,152	Bouvier (2000), 6% impact; Zillow median price for counties with majority of sites is $346,148; 20 homes assumed
Public Health Impacts	HH	0	$0	$0	$0	$0	Unknown
Indirect Cost Sub-Total				$3,940,313	$3,388,692	$2,945,152	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of transport
GHGs from Landfilled Biosolids	kg / ton		$0	$0	$0	$0	None, land applied
GHGs from Land-Applied Biosolids	kg	1,000	$21,782	$206,630	$177,703	$154,444	From the lesser of two estimates
Well Contamination	HH / yr	0	$0	$0	$0	$0	None evaluated
Shadow Price of Nutrient Pollution (N)	lb / yr	55,000	$101,168	$959,686	$825,336	$717,309	At 100 lb TN per ton dry biosolids applied; least cost treatment; 1000 tons; 55% mineralization
Shadow Price of Nutrient Pollution (P)	lb / yr	24,200	$882,259	$8,369,194	$7,197,555	$6,255,479	At 44 lb TP per ton dry biosolids applied; least cost treatment; 1000 tons; 55% mineralization
Non-Market Cost Sub-Total				$9,606,217	$8,261,402	$7,180,081	
Total Costs				$18,818,880	$16,192,973	$14,081,571	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Recovered Phosphorus	kg / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Electric Revenues	kwh / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Compost Revenues	per ton	0	$0	$0	$0	$0	Not Applicable
Avoided Costs for Fertilizer	per ac	851	$51,060	$484,360	$416,553	$362,031	Based on DEP estimate of 1.175 T/ac and $60/ac
Avoided Treatment Costs - N	lb-N / yr	0	$0	$0	$0	$0	Not Applicable
Avoided Treatment Costs - P	lb-P / yr	0	$0	$0	$0	$0	Not Applicable
Avoided Landfill Costs	per ton	1,000	$71,530	$678,541	$583,549	$507,169	Miami Dade, value of landfill capacity
Residual Value	per system	0	$0	$0	$0	$0	Not Applicable
Direct Benefits Sub-Total:				$1,162,901	$1,000,101	$869,200	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	per HH	0	$0	$0	$0	$0	None
Community values (aesthetics, recreation & tourism)	per person	0	$0	$0	$0	$0	None
Soil Organic Matter	$ / ton	1,000	$9,880	$93,726	$80,605	$70,054	0.1% application increment
Non-Market Benefits Sub-Total				$93,726	$80,605	$70,054	
Total Benefits				$1,256,627	$1,080,706	$939,254	

Results			
Net Benefits	**($17,562,253)**	**($15,112,267)**	**($13,142,316)**
Benefit:Cost Ratio	0.06677	0.06674	0.06670

Appendix H. Benefit Cost Analysis (Continued)

Conventional Composting

Biosolids Benefit:Cost Analysis

Alt. #3: Conventional Wastewater Treatment Facility & Composting of Class B Biosolids (per additional increment of 1000 Dry Tons)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0.66	$42,627	$28,134	$28,134	$28,134	Based on Coker, 0.66 acre for a facility that yields ~1000 T/yr; price per acre for industrial is $64,587 (https://www.landsearch.com/industrial/florida)
Design & Permitting Costs	per system	1	$14,058	$14,058	$14,058	$14,058	10% assumed for design and permitting; https://floridadep.gov/sites/default/files/Domestic_Wastewater_Permit_Applications_Fees_0.pdf
System Purchase (CAPEX)	per system	1	$140,581	$140,581	$140,581	$140,581	EPA (2000)
O&M / Repair (OPEX)	per ton	1,000	$702,904	$6,667,814	$5,734,358	$4,983,798	EPA (2000)
Replacement (Life-Cycle)	per year	0.07	$10,683	$101,340	$87,153	$75,746	Based on 15-year lifespan; transport equipment only
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	0	$0	$0	$0	$0	Not Applicable, composted
Transport of Biosolids	per ton	1,000	$37,848	$359,027	$308,765	$268,351	Based on DEP SERC, 30 miles one-way
Spreading of Biosolids	per ton	1,000		$0	$0	$0	Not Applicable, composted
Direct Cost Sub-Total				**$9,622,421**	**$8,300,924**	**$7,238,353**	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	-	$0	$0	$0	$0	Odor, Public Perception
Public Health Impacts	HH						Unknown
Indirect Cost Sub-Total				**$0**	**$0**	**$0**	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of transport
GHGs from Landfilled Biosolids	kg / ton		$0	$0	$0	$0	None, land applied
GHGs from Land-Applied Biosolids	kg	1,000	$0	$0	$0	$0	
Well Contamination	HH / yr	0	$0	$0	$0	$0	America Chemical Society life-cycle costs of waste
Shadow Price of Nutrient Pollution (N)	lb / yr	55,000	$101,168	$959,686	$825,336	$717,309	At 100 lb residual N per ton dry biosolids applied; 1000 tons; least cost treatment; 55% mineralization
Shadow Price of Nutrient Pollution (P)	lb / yr	12,100	$441,129	$4,184,597	$3,598,777	$3,127,739	At 22 lb TP per ton dry biosolids applied; 1000 tons; 55% mineralization
Non-Market Cost Sub-Total				**$5,214,990**	**$4,484,921**	**$3,897,897**	
Total Costs				**$14,837,411**	**$12,785,845**	**$11,136,250**	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Recovered Phosphorus	kg / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Electric Revenues	kwh / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Compost Revenues	per ton	1,000	$34,205	$324,468	$279,044	$242,521	EPA (2002)
Avoided Costs for Fertilizer	per ac	851	$51,060	$484,360	$416,553	$362,031	Offset to use otherwise; Based on DEP estimate of 1.175 T/ac and $60/ac
Avoided Treatment Costs - N	lb-N / yr	99,000	$182,102	$1,727,436	$1,485,604	$1,291,156	Per DEP Stormwater Project Costs per lb; 5.5% nitrogen; Leach rate of 10%
Avoided Treatment Costs - P	lb-P / yr	39,600	$130,680	$1,239,644	$1,066,101	$926,560	Per DEP Stormwater Project Costs per lb; 2.2% phosphorus; Leach rate of 10%
Avoided Landfill Costs	per ton	1,000	$71,530	$678,541	$583,549	$507,169	Miami Dade, value of landfill capacity
Residual Value	per system	0	$0	$0	$0	$0	Not Applicable
Direct Benefits Sub-Total				**$4,454,448**	**$3,830,851**	**$3,329,437**	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	per HH	20,468	$151,717	$1,439,201	$1,237,721	$1,075,718	EPA / Florida Study; Based on total biosolids produced and 7.931M households (2021); adjusted for mineralization rate
Community values (aesthetics, recreation & tourism)	per person		$0	$0	$0	$0	Included in WTP
Soil Organic Matter	$ / ton	1,000	$19,761	$187,451	$161,209	$140,109	Composted rate assumed to be dounble that for Class B
Non-Market Benefits Sub-Total				$1,626,652	$1,398,930	$1,215,827	
Total Benefits				$6,081,100	$5,229,781	$4,545,264	

Results			
Net Benefits	**($8,756,311)**	**($7,556,064)**	**($6,590,986)**
Benefit:Cost Ratio	0.4098	0.4090	0.4082

Appendix H. Benefit Cost Analysis (Continued)

Conversion to Class AA

Biosolids Benefit:Cost Analysis

Alt. #4: Conventional Wastewater Treatment Facility & Conversion to Class AA (per additional increment of 1000 Dry Tons)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0.66	$42,627	$28,134	$28,134	$28,134	Based on Coker, 0.66 acre for a facility that yields ~1000 T/yr; price per acre for industrial is $64,587 (https://www.landsearch.com/industrial/florida)
Design & Permitting Costs	per system	1	$457,447	$457,447	$457,447	$457,447	10% assumed for design and permitting; https://floridadep.gov/sites/default/files/Domestic_Wastewater_Permit_Applications_Fees_0.pdf
System Purchase (CAPEX)	per system	1	$4,574,468	$4,574,468	$4,574,468	$4,574,468	Based on DEP SERC, $430M per 94,000 tons
O&M / Repair (OPEX)	per ton	0.10	$457,447	$4,339,386	$3,731,897	$3,243,435	Based on DEP SERC, 10% of capital costs
Replacement (Life-Cycle)	per year	0.07	$10,683	$101,340	$87,153	$75,746	Based on 15-year lifespan; transport equipment only
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	0	$0	$0	$0	$0	Not Applicable, composted
Transport of Biosolids	per ton	1,000	$37,848	$359,027	$308,765	$268,351	Based on DEP SERC, 30 miles one-way to facility
Spreading of Biosolids	per ton	0	$0	$0	$0	$0	Not Applicable, composted
Direct Cost Sub-Total				**$12,171,269**	**$11,175,738**	**$10,375,266**	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	-	$0	$0	$0	$0	Odor, Public Perception
Public Health Impacts	HH						Unknown
Indirect Cost Sub-Total				**$0**	**$0**	**$0**	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of transport
GHGs from Landfilled Biosolids	kg / ton		$0	$0	$0	$0	None, land applied
GHGs from Land-Applied Biosolids	kg	1,000	$0	$0	$0	$0	
Well Contamination	HH / yr	0	$0	$0	$0	$0	America Chemical Society life-cycle costs of waste
Shadow Price of Nutrient Pollution (N)	lb / yr	33,440	$61,510	$583,489	$501,804	$436,124	Nitrogen content lowered to 4.4%; 38% mineralization
Shadow Price of Nutrient Pollution (P)	lb / yr	7,600	$277,073	$2,628,342	$2,260,389	$1,964,531	Phosphorus content lowered to 2.0%; 38% mineralization
Non-Market Cost Sub-Total				**$3,282,538**	**$2,823,001**	**$2,453,503**	
Total Costs				**$15,453,807**	**$13,998,740**	**$12,828,769**	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Recovered Phosphorus	kg / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Electric Revenues	kwh / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Class AA Revenues	per ton	1,000	$86,047	$816,248	$701,978	$610,097	USDA, 2009
Avoided Costs for Fertilizer	per ac	851	$51,060	$484,360	$416,553	$362,031	Offset to use otherwise; Based on DEP estimate of 1.175 T/ac and $60/ac
Avoided Treatment Costs - N	lb-N / yr	19,800	$36,420	$345,487	$297,121	$258,231	Per DEP Stormwater Project Costs per lb; 5.5% nitrogen; Leach rate of 10%
Avoided Treatment Costs - P	lb-P / yr	1,800	$5,940	$56,347	$48,459	$42,116	Per DEP Stormwater Project Costs per lb; 2.3% phosphorus; Leach rate of 10%
Avoided Landfill Costs	per ton	1,000	$71,530	$678,541	$583,549	$507,169	Miami Dade, value of landfill capacity
Residual Value	per system	1	$2,287,234	$2,287,234	$2,287,234	$2,287,234	50% of Capital Costs
Direct Benefits Sub-Total				**$4,668,217**	**$4,334,893**	**$4,066,878**	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	per HH	20,468	$110,117	$1,044,582	$898,346	$780,763	EPA / Florida Study; Based on total biosolids produced and 7.931M households (2021); includes groundwater; adjusted for mineralization rate
Community values (aesthetics, recreation & tourism)	per person		$0	$0	$0	$0	Included in WTP
Soil Organic Matter	$ / ton	1000	$9,880	$93,726	$80,605	$70,054	Assumed equal rate to Class B
Non-Market Benefits Sub-Total				$1,138,307	$978,951	$850,817	
Total Benefits				$5,806,524	$5,313,844	$4,917,696	

Results			
Net Benefits	**($9,647,282)**	**($8,684,896)**	**($7,911,074)**
Benefit:Cost Ratio	0.3757	0.3796	0.3833

Appendix H. Benefit Cost Analysis (Continued)

High Quality, Extended Composting

Biosolids Benefit:Cost Analysis

Alt. #4: Conventional Wastewater Treatment Facility & High Quality Composting (per additional increment of 1000 Dry Tons)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0.66	$42,627	$28,134	$28,134	$28,134	Based on Coker, 0.66 acre for a facility that yields ~1000 T/yr; price per acre for industrial is $64,587 (https://www.landsearch.com/industrial/florida)
Design & Permitting Costs	per system	1	$23,477	$23,477	$23,477	$23,477	10% assumed for design and permitting; https://floridadep.gov/sites/default/files/Domestic_Wastewater_Permit_Applications_Fees_0.pdf
System Purchase (CAPEX)	per system	1	$234,770	$234,770	$234,770	$234,770	Adjusted +67% for additional composted time
O&M / Repair (OPEX)	per ton	1,000	$697,618	$6,617,670	$5,691,234	$4,946,318	Based on added capacity over pilots, EPA (2000)
Replacement (Life-Cycle)	per year	0.07	$10,683	$101,340	$87,153	$75,746	Based on 15-year lifespan; transport equipment only
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	0	$0	$0	$0	$0	Not Applicable, composted
Transport of Biosolids	per ton	1,000	$37,848	$359,027	$308,765	$268,351	Based on DEP SERC, 30 miles one-way to facility
Spreading of Biosolids	per ton	0	$0	$0	$0	$0	Not Applicable, composted
Direct Cost Sub-Total				**$9,675,885**	**$8,361,408**	**$7,304,481**	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	-	$0	$0	$0	$0	Odor, Public Perception
Public Health Impacts	HH						Unknown
Indirect Cost Sub-Total				**$0**	**$0**	**$0**	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of transport
GHGs from Landfilled Biosolids	kg / ton		$0	$0	$0	$0	None, land applied
GHGs from Land-Applied Biosolids	kg	1,000	$0	$0	$0	$0	
Well Contamination	HH / yr	0	$0	$0	$0	$0	America Chemical Society life-cycle costs of waste
Shadow Price of Nutrient Pollution (N)	lb / yr	3,600	$6,622	$62,816	$54,022	$46,951	Nitrogen content lowered to 1%; 18% mineralization
Shadow Price of Nutrient Pollution (P)	lb / yr	1,800	$65,623	$622,502	$535,355	$465,284	Phosphorus content lowered to 0.5%; 18% mineralization
Non-Market Cost Sub-Total				**$756,024**	**$650,185**	**$565,084**	
Total Costs				**$10,431,909**	**$9,011,593**	**$7,869,565**	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Recovered Phosphorus	kg / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Electric Revenues	kwh / 1E3 ton	0	$0	$0	$0	$0	None Recovered
Compost Revenues	per ton	1,000	$86,047	$816,248	$701,978	$610,097	USDA, 2009
Avoided Costs for Fertilizer	per ac	851	$51,060	$484,360	$416,553	$362,031	Offset to use otherwise; Based on DEP estimate of 1.175 T/ac and $60/ac
Avoided Treatment Costs - N	lb-N / yr	81,000	$148,992	$1,413,356	$1,215,495	$1,056,400	Per DEP Stormwater Project Costs per lb; 5.5% nitrogen; Leach rate of 10%
Avoided Treatment Costs - P	lb-P / yr	32,400	$106,920	$1,014,254	$872,264	$758,095	Per DEP Stormwater Project Costs per lb; 2.3% phosphorus; Leach rate of 10%
Avoided Landfill Costs	per ton	1,000	$71,530	$678,541	$583,549	$507,169	Miami Dade, value of landfill capacity
Residual Value	per system	1	$117,385	$117,385	$117,385	$117,385	50% of Capital Costs
Direct Benefits Sub-Total				**$4,524,144**	**$3,907,222**	**$3,411,177**	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	per HH	20,468	$232,469	$2,205,228	$1,896,508	$1,648,278	EPA / Florida Study; Based on total biosolids produced and 7.931M households (2021); includes groundwater; adjusted for mineralization rate
Community values (aesthetics, recreation & tourism)	per person		$0	$0	$0	$0	Included in WTP
Soil Organic Matter	$/ton	1,000	$39,521	$374,902	$322,418	$280,217	Rate assumed to be four times that for Class B
Non-Market Benefits Sub-Total				$2,580,130	$2,218,927	$1,928,495	
Total Benefits				$7,104,274	$6,126,149	$5,339,672	

Results			
Net Benefits	**($3,327,635)**	**($2,885,444)**	**($2,529,893)**
Benefit:Cost Ratio	0.6810	0.6798	0.6785

Appendix H. Benefit Cost Analysis (Continued)

Vapor Recompression and Distillation (Sedron Process)

Biosolids Benefit:Cost Analysis

Alt. #5: Conventional Wastewater Treatment Facility & Processing via Sedron Technology (per additional increment of 1000 Dry Tons per year*)

				10 Year Horizon			
Direct Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Land Costs	acre	0.046	$2,971	$137	$137	$137	Single VRD unit requires 2013 sq ft (0.046 ac); price per acre for industrial is $64,587 (https://www.landsearch.com/industrial/florida)
Design & Permitting Costs	per system	1	$197,127	$197,127	$197,127	$197,127	10% assumed for design and permitting; https://floridadep.gov/sites/default/files/Domestic_Wastewater_Permit_Applications_Fees_0.pdf
System Purchase (CAPEX)	per system	1	$1,953,268	$1,953,268	$1,953,268	$1,953,268	2017 data adjusted by 1.20 for Construction Cost Index vs CPI; includes share of power plant
O&M / Repair (OPEX)	per ton	1,000	$220,087	$2,087,763	$1,795,488	$1,560,480	2017 data adjusted by 1.20 for Construction Cost Index vs CPI
Replacement (Life-Cycle)	per year	0.10	$19,229	$182,412	$156,875	$136,342	Based on 10-year lifespan
De-Watering & Drying Costs	per ton	1,000	$243,669	$2,311,467	$1,987,875	$1,727,685	Based on O&M at Miami-Dade for 297 mgd
Landfilling of Biosolids & Byproducts	per ton	0	$0	$0	$0	$0	Not Applicable
Transport of Biosolids	per ton	1,000	$18,924	$179,513	$154,383	$134,176	Based on DEP state-level estimates; assumes local and not regional facility
Spreading of Biosolids	per ton	0		$0	$0	$0	Not Applicable
Direct Cost Sub-Total				**$6,911,687**	**$6,245,152**	**$5,709,214**	
Indirect Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
Property Value Impacts	HH	0	$0	$0	$0	$0	Odor, Public Perception
Public Health Impacts	HH						Unknown
Indirect Cost Sub-Total				**$0**	**$0**	**$0**	
Non-Market Costs	**Units**	**Quantity**	**One Time/ Annual Cost**	**Total Cost 4%**	**Total Cost 7%**	**Total Cost 10%**	**Comments**
GHGs from Transport	kg / ton	1,000	$7,454	$70,706	$60,808	$52,849	Based on ton-miles of local transport
GHGs from Landfilled Biosolids	kg / ton	1,000	$86,068	$816,451	$702,153	$610,249	Not Applicable
GHGs from Land-Applied Biosolids	kg	0	$0	$0	$0	$0	Not Applicable
Well Contamination	HH / yr	0	$0	$0	$0	$0	Not Applicable
Shadow Price of Nutrient Pollution (N)	lb / yr	0	$0	$0	$0	$0	Not Applicable
Non-Market Cost Sub-Total				**$887,158**	**$762,961**	**$663,098**	
Costs Total				**$7,798,845**	**$7,008,113**	**$6,372,312**	

				10 Year Horizon			
Direct Benefits	**Units**	**Quantity**	**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	
Ammonia Solution	gal / 1E3 ton	4,883	$12,705	$120,518	$103,646	$90,080	Market Rate; Based on 4400 lb of ammonia per 14700 lb of dry biosolids and 8.34 lb/gal
Recovered Phosphorus	kg / 1E3 ton	19,884	$11,507	$109,158	$93,876	$81,589	Market Rate; Based on 1200 lb of phosphorus per 14,700 lb of dry biosolids
Electric Revenues	kwh / 1E3 ton	791,781	$37,863	$359,172	$308,890	$268,460	Based on 5MW for 54750 dry tons and 8.67E6 KWH per MW
Avoided Costs for Fertilizer	per ac		$0	$0	$0	$0	Not Applicable
Avoided Treatment Costs - N	lb-N / yr	110,000	$202,335	$1,919,373	$1,650,672	$1,434,618	Per DEP Stormwater Project Costs per kg (Appendix J)
Avoided Treatment Costs - P	lb-P / yr	44,000	$145,200	$1,377,382	$1,184,556	$1,029,512	
Avoided Landfill Costs	per ton	1,000	$71,530	$678,541	$583,549	$507,169	Miami Dade, value of landfill capacity
Residual Value	per system	1	$976,634	$976,634	$976,634	$976,634	Straightline depreciation; 20-year life assumed
Direct Benefits Sub-Total				$5,540,777	$4,901,823	$4,388,061	
Non-Market Benefits			**Unit Value**	**Total Benefits 4%**	**Total Benefits 7%**	**Total Benefits 10%**	**Comments**
WTP for Surface Water Quality / Clarity	$/HH	20,468	$244,705	$2,321,292	$1,996,325	$1,735,029	EPA / Florida Study; Based on total biosolids produced and 7.931M households (2021)
Community values (aesthetics, recreation & springs tourism)	$/person	0	$39	$366	$315	$274	Included in WTP
Non-Market Benefits Sub-Total				$2,321,658	$1,996,639	$1,735,303	
Total Benefits				$7,862,435	$6,898,462	$6,123,364	

Results			
Net Benefits	$63,591	($109,651)	($248,948)
Benefit:Cost Ratio	1.0082	0.9844	0.9609

* Downscaled from 2017 estimates based upon 54,750 dry tons/year; newer data not provided

Appendix H. Benefit Cost Analysis (Continued)

REFERENCE VALUES, BIOSOLIDS MANAGEMENT OPTIONS

Item	Unit	Base Year	Base Value	CPI Factor	2023 Value Per Year	Source	Comment
Landfill Costs	$/ton	2019	$48	1.20	$57.77	https://floridadep.gov/waste/waste-reduction/documents/2019-florida-solid-waste-disposal-fees	State Average used; Miami-Dade is currently $71.53
Transport Costs	$/ton-mile	2022	$0.60	1.05	$0.63	DEP 62-640 SERC	Based on SERC estimate of $27M for 90K dry tons and 500 miles @ $3/mile (250 miles one-way).
Local Transport Costs	$/ton-mile	2022	$0.60	1.05	$0.63	DEP 62-640 SERC	Based on SERC estimate of $27M for 90K dry tons and 500 miles @ $3/mile (250 miles one-way). Estimated round trip of 30 miles in hypothetical, average county of 981 sq mi
WWTP O&M	$/ton	2020	$205	1.19	$244	DEP 62-640 SERC	Miami-Dade O&M was $10M for ~48,787 tons based on 0.4 dry tons per 1 mgd, 297 mgd in 2006, 2.406M population in 2006 and 2.707M in 2020
De-watering Costs	$/ton	2020		1.19	$0.00		
Drying Costs	$/ton	2022		1.05	$0.00		
Windrow Composting Capital	$/ton	2002	$82,200	1.71	$140,581	USEPA (2002)	Based on $30,000 per ton per day
In-Vessel Composting	$/ton	2000	$521	1.79	$930	USEPA (2000)	Average O&M costs over range
Windrow Composting	$/ton	2002	$411	1.71	$703	USEPA (2002)	Based on $150 per ton per day; 1000 ton over 365 days
Compost Revenues	$/ton	2002	$20	1.71	$34	USEPA (2002)	
Class AA Revenues	$/ton	2009	$60	1.43	$86	USDA (2009)	ECONOMICS FL - 9; December 2009
Varcar System	$/1000 tons	2017	$1,022,831	1.26	$1,283,838	Sedron Technologies	Based on 2017 cost data at $56 million for capacity of 54,750 ton/yr
Varcar 5MW Power Plant	$/1000 tons	2017	$273,973	1.26	$343,885	Sedron Technologies	Based on 2017 cost data at $15 million for output from Varcor units with capacity of 54,750 tons
Varcor O&M	$/ton	2017	$146	1.26	$183.41	Sedron Technologies	Based on 2017 cost data at $8 million for 7 units with capacity of 54,750 ton/yr
Electric Costs	$/KWH	2023		1.00	$0.00	https://www.fpl.com/content/dam/fplgp/us/en/rates/pdf/bus-jan-2023.pdf	Category GSLDT-1 combined costs & credits are 6.317 cents / kwh, plus $88/mo base fee.
Electric Revenues	$/KWH	2023	$0.04782	1.00	$0.05	Janicki; Roderick	Updated for FPL Wholesale Rate (GSLDT-3)
Ammonia Revenues	$/gallon	2022	$2.47	1.05	$2.60	https://medium.com/intratec-products-blog/ammonia-prices-latest-historical-data-in-several-countries-8c16d21afd0b#:~:text=United%20States.,the%20price%20one%20quarter%20before.	2022 market price was $1084 per metric ton (438 gallons) Janicki estimates 4400 lb per 14,700 dry tons; 299.3 lb per 1000 ton; 35.9 gal per 1000 ton
Nitrogen Recovery	$/kg	2023	$0.24	1.00	$0.24	https://www.dtnpf.com/agriculture/web/ag/crops/article/2023/08/21/wholesale-fertilizer-prices-higher	2023 market price is $385-415 per ton for urea ammonium nitrate
Phosphorus Recovery	$/kg	2023	$0.58	1.00	$0.58	https://www.dtnpf.com/agriculture/web/ag/crops/article/2023/08/21/wholesale-fertilizer-prices-higher	2023 market price is $220-225 per ton FOB; urea is $440-475/t FOB
GHGs - Transport (CO_2)	$/ton	2020	$6	1.19	$7.45	https://business.edf.org/insights/green-freight-math-how-to-calculate-emissions-for-a-truck-move/ https://www.rff.org/news/press-releases/social-cost-of-carbon-more-than-triple-the-current-federal-estimate-new-study-finds/#:~:text=The%20study%2C%20published%20today%20in,estimate%20of%20%2451%20per%20ton.	Distance from Miami-Dade to Osceola County is 194 miles. Annual transfer is 13,716 dry tons. Per EDF, tankers emit 1750 g of CO_2/mile and trucks emit 161.8 g/ton-mile. 475 tons one way; 950 tons two-way. At $181/ ton, $85,975 for 13716 tons, or $6.27 per ton
GHGs - Landfill (CO_2)	$/ton	2020	$72	1.19	$86.07	https://pubs.acs.org/doi/10.1021/acs.est.0c00364#:~:text=Landfilling%20is%20the%20most%20greenhouse,per%20tonne%20of%20organic%20waste.	400 kg/ton At $181 per ton, $72
GHGs - Landfill (Methane)		2019	$108	1.20	$129.97	http://gwcouncil.org/wp-content/uploads/2019/06/Methane-Emissions-from-Landfills-Haokai-Zhao.pdf	0.072 ton/ton At $1500 per ton, $108 per ton
GHGs - Land Application (CO_2)	$/ton	2019	$18	1.20	$21.78	https://climatesmartwater.org/wp-content/uploads/sites/2/2019/01/Calculator-Tool-for-Determining-Greenhouse-Gas-Emissions-for-Biosolids-Processing-and-End-Use.pdf	10Mg CO_2e/100Mg: one tenth of the price per ton a second example yielded 28Mg CO_2e/100Mg
Biosolids (Manure) Shed	$	2021	$35,328	1.14	$40,113	2021 SWFWMD Model Farms Study	Costs for interim storage
Biosolids Spreader	$	2024	$6,530	1.00	$6,530	https://www.wengers.com/agriculture/farm-equipment/manure-spreaders.html	Current costs from farm supplier; average of 17 models is $6530
Transport Truck - 25 yd	$	2006	$105,000	1.53	$160,245	Alachua County Biosolids Management Plan	Current price for 13 ton Trailer (alone) is $24,899. https://trailernation.com/product/big-tex-8x20-dump-trailer-25du-20/
Transport Truck - Highway Trailer	$	2008	$141,000	1.43	$201,490	Alachua County Biosolids Management Plan	Current price for 25 ton Trash Freightliner is $286900 https://www.trashtrucksonline.com/category/GARBAGE-TRUCKS/Rear-Loaders/listings/25255/2023-Freightliner-M2-106,-25-Yd-Pac-Tech-Rear-Loader
Transport Maintenance	$/mi	2018	$1	1.23	$1.69	https://www.imiproducts.com/blog/the-cost-of-trucking/	Composite costs for truck use (fixed, variable and labor).
Spreader Operating	$/ac	2018	$6	1.23	$7.66	https://talk.newagtalk.com/forums/thread-view.asp?tid=758867&DisplayType=nested&setCookie=1	Typical costs for manure and biosolids spreading; DEP SERC reports $8/ac. Average used
Total Nitrogen Removed	$/lb/yr	2009	$400	1.43	$572.96	FDEP Grant Files	Average cost to remove 1 lb/yr of TN across 40 DEP stormwater grants; mean value of $9,080, 50 yr lifespan
Total Nitrogen Removed	$/lb/yr	2021	$2	1.14	$1.84	2021 SWFWMD Model Farms Study	Least cost among alternatives for livestock and grazing facilities
Total Phosphorus Removed	$/lb/yr	2009	$400	1.43	$572.96	FDEP Grant Files	Average cost to remove 1 lb/yr of TP across 40 DEP stormwater grants; mean value of $9,080, 50 yr lifespan
Total Phosphorus Removed	$/lb/yr	2023	$3	1.00	$3.30	FDEP 2023-24 Water Quality Improvement Projects List	Minimum cost of $26/ton; adjusted average cost of $6,600
Shadow Price of Phosphorus	$/lb	2010	$26	1.41	$36.46	Molinos-Senante, et.al. 2010. AMBIO (2011) 40:408–416	€42.74 per kg; Euro was worth $1.33 US in 2010.
WTP for Surface Water Quality / Clarity	per household	2010	$2.94	1.41	$4.15	Florida Flowing Waters. (Page 132) Link: https://www.epa.gov/sites/production/files/2015-07/documents/florida-economic-anaylis-report.pdf	
WTP for Ground Water Quality	per household	2017	$6.22	1.26	$7.81	Chiradip Chatterjee*, Russell Triplett, Christopher K. Johnson, Parvez Ahmed. Willingness to Pay for Safe Drinking Water : A Contingent Valuation in Jacksonville FL	
Community values (aesthetics, recreation & springs tourism)	Per Person	2018	$31.50	1.23	$38.60	"Valuing Recreation Benefits of Natural Springs in Florida." Qianyan Wu, Xiang Bi, Kelly Grogan, and Tatiana Borisova	Annual consumer surplus per person per trip is between $20 and $43. Furthermore, visitors are willing to contribute $12 to $14 per person per trip for springs restoration without reducing trip demand.
Value of Landfill Capacity	$/ton	2020	$28.13	1.19	$33.44	Costs for additional capacity, Escambia County	$7.6 million for 443,000 cy; wet sludge density at 0.61 T/cy.
Value of Soil Organic Matter	$/ton	2019	$8.21	1.20	$9.88	Morris, UT Extension	Based on 0.1% additional soil organic matter and includes benefits of water retention, yield and avoided soil loss. 0.1% is equivalent to one ton over one acre. Excludes value of nutrients.

Appendix I. Florida Laws Governing Biosolids, as of April, 2024[1]

373.4595 Northern Everglades and Estuaries Protection Program.—

(1) FINDINGS AND INTENT.—

(a) The Legislature finds that the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed are critical water resources of the state, providing many economic, natural habitat, and biodiversity functions benefiting the public interest, including agricultural, public, and environmental water supply; flood control; fishing; navigation and recreation; and habitat to endangered and threatened species and other flora and fauna.

(b) The Legislature finds that changes in land uses, the construction of the Central and Southern Florida Project, and the loss of surface water storage have resulted in adverse changes to the hydrology and water quality of Lake Okeechobee and the Caloosahatchee and St. Lucie Rivers and their estuaries.

(c) The Legislature finds that improvement to the hydrology, water quality, and associated aquatic habitats within the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed, is essential to the protection of the greater Everglades ecosystem.

(d) The Legislature also finds that it is imperative for the state, local governments, and agricultural and environmental communities to commit to restoring and protecting the surface water resources of the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed, and that a watershed-based approach to address these issues must be developed and implemented immediately.

(e) The Legislature finds that phosphorus loads from the Lake Okeechobee watershed have contributed to excessive phosphorus levels throughout the Lake Okeechobee watershed and downstream receiving waters and that a reduction in levels of phosphorus will benefit the ecology of these systems. The excessive levels of phosphorus have also resulted in an accumulation of phosphorus in the sediments of Lake Okeechobee. If not removed, internal phosphorus loads from the sediments are expected to delay responses of the lake to external phosphorus reductions.

(f) The Legislature finds that the Lake Okeechobee phosphorus loads set forth in the total maximum daily loads established in accordance with s. 403.067 represent an appropriate basis for restoration of the Lake Okeechobee watershed.

(g) The Legislature finds that, in addition to phosphorus, other pollutants are contributing to water quality problems in the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed, and that the total maximum daily load requirements of s. 403.067 provide a means of identifying and addressing these problems.

(h) The Legislature finds that the expeditious implementation of the Lake Okeechobee Watershed Protection Program, the Caloosahatchee River Watershed Protection Program, and the St. Lucie River Watershed Protection Program is needed to improve the quality, quantity, timing, and distribution of water in the northern Everglades ecosystem and that this section, in conjunction with s. 403.067, including the implementation of the plans developed and approved pursuant to subsections (3) and (4), and any related basin management action plan developed and implemented pursuant to s. 403.067(7)(a), provide a reasonable means of achieving the total maximum daily load requirements and achieving and maintaining compliance with state water quality standards.

[1] Includes statutes enacted in 2023.

(i) The Legislature finds that the implementation of the programs contained in this section is for the benefit of the public health, safety, and welfare and is in the public interest.

(j) The Legislature finds that sufficient research has been conducted and sufficient plans developed to immediately expand and accelerate programs to address the hydrology and water quality in the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed.

(k) The Legislature finds that a continuing source of funding is needed to effectively implement the programs developed and approved under this section which are needed to address the hydrology and water quality problems within the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed.

(l) It is the intent of the Legislature to protect and restore surface water resources and achieve and maintain compliance with water quality standards in the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed, and downstream receiving waters, through the phased, comprehensive, and innovative protection program set forth in this section which includes long-term solutions based upon the total maximum daily loads established in accordance with s. 403.067. This program shall be watershed-based, shall provide for consideration of all water quality issues needed to meet the total maximum daily load, and shall include research and monitoring, development and implementation of best management practices, refinement of existing regulations, and structural and nonstructural projects, including public works.

(m) It is the intent of the Legislature that this section be implemented in coordination with the Comprehensive Everglades Restoration Plan project components and other federal programs in order to maximize opportunities for the most efficient and timely expenditures of public funds.

(n) It is the intent of the Legislature that the coordinating agencies encourage and support the development of creative public-private partnerships and programs, including opportunities for water storage and quality improvement on private lands and water quality credit trading, to facilitate or further the restoration of the surface water resources of the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed, consistent with s. 403.067.

(2) DEFINITIONS.—As used in this section, the term:

(a) “Best management practice” means a practice or combination of practices determined by the coordinating agencies, based on research, field-testing, and expert review, to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality in agricultural and urban discharges. Best management practices for agricultural discharges shall reflect a balance between water quality improvements and agricultural productivity.

(b) “Biosolids” means the solid, semisolid, or liquid residue generated during the treatment of domestic wastewater in a domestic wastewater treatment facility, formerly known as “domestic wastewater residuals” or “residuals,” and includes products and treated material from biosolids treatment facilities and septage management facilities regulated by the department. The term does not include the treated effluent or reclaimed water from a domestic wastewater treatment facility, solids removed from pump stations and lift stations, screenings and grit removed from the preliminary treatment components of domestic wastewater treatment facilities, or ash generated during the incineration of biosolids.

(c) “Caloosahatchee River watershed” means the Caloosahatchee River, its tributaries, its estuary, and the area within Charlotte, Glades, Hendry, and Lee Counties from which surface water flow is directed or drains, naturally or by constructed works, to the river, its tributaries, or its estuary.

(d) “Coordinating agencies” means the Department of Agriculture and Consumer Services, the Department of Environmental Protection, and the South Florida Water Management District.

(e) "Corps of Engineers" means the United States Army Corps of Engineers.

(f) "Department" means the Department of Environmental Protection.

(g) "District" means the South Florida Water Management District.

(h) "Lake Okeechobee Watershed Construction Project" means the construction project developed pursuant to this section.

(i) "Lake Okeechobee Watershed Protection Plan" means the Lake Okeechobee Watershed Construction Project and the Lake Okeechobee Watershed Research and Water Quality Monitoring Program.

(j) "Lake Okeechobee watershed" means Lake Okeechobee, its tributaries, and the area within which surface water flow is directed or drains, naturally or by constructed works, to the lake or its tributaries.

(k) "Northern Everglades" means the Lake Okeechobee watershed, the Caloosahatchee River watershed, and the St. Lucie River watershed.

(l) "Project component" means any structural or operational change, resulting from the Restudy, to the Central and Southern Florida Project as it existed and was operated as of January 1, 1999.

(m) "Restudy" means the Comprehensive Review Study of the Central and Southern Florida Project, for which federal participation was authorized by the Federal Water Resources Development Acts of 1992 and 1996 together with related Congressional resolutions and for which participation by the South Florida Water Management District is authorized by s. 373.1501. The term includes all actions undertaken pursuant to the aforementioned authorizations which will result in recommendations for modifications or additions to the Central and Southern Florida Project.

(n) "River Watershed Protection Plans" means the Caloosahatchee River Watershed Protection Plan and the St. Lucie River Watershed Protection Plan developed pursuant to this section.

(o) "Soil amendment" means any substance or mixture of substances sold or offered for sale for soil enriching or corrective purposes, intended or claimed to be effective in promoting or stimulating plant growth, increasing soil or plant productivity, improving the quality of crops, or producing any chemical or physical change in the soil, except amendments, conditioners, additives, and related products that are derived solely from inorganic sources and that contain no recognized plant nutrients.

(p) "St. Lucie River watershed" means the St. Lucie River, its tributaries, its estuary, and the area within Martin, Okeechobee, and St. Lucie Counties from which surface water flow is directed or drains, naturally or by constructed works, to the river, its tributaries, or its estuary.

(q) "Total maximum daily load" means the sum of the individual wasteload allocations for point sources and the load allocations for nonpoint sources and natural background adopted pursuant to s. 403.067. Before determining individual wasteload allocations and load allocations, the maximum amount of a pollutant that a water body or water segment can assimilate from all sources without exceeding water quality standards must first be calculated.

(3) LAKE OKEECHOBEE WATERSHED PROTECTION PROGRAM.—The Lake Okeechobee Watershed Protection Program shall consist of the Lake Okeechobee Watershed Protection Plan, the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067, the Lake Okeechobee Exotic Species Control Program, and the Lake Okeechobee Internal Phosphorus Management Program. The Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067 shall be the component of the Lake Okeechobee Watershed Protection Program that achieves phosphorus load reductions for Lake Okeechobee. The Lake Okeechobee Watershed Protection Program shall address the reduction of phosphorus loading to the lake from both internal and external sources. Phosphorus load reductions shall be achieved through a phased program of

implementation. In the development and administration of the Lake Okeechobee Watershed Protection Program, the coordinating agencies shall maximize opportunities provided by federal cost-sharing programs and opportunities for partnerships with the private sector.

(a) *Lake Okeechobee Watershed Protection Plan.*—To protect and restore surface water resources, the district, in cooperation with the other coordinating agencies, shall complete a Lake Okeechobee Watershed Protection Plan in accordance with this section and ss. 373.451-373.459. Beginning March 1, 2020, and every 5 years thereafter, the district shall update the Lake Okeechobee Watershed Protection Plan to ensure that it is consistent with the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067. The Lake Okeechobee Watershed Protection Plan shall identify the geographic extent of the watershed, be coordinated with the plans developed pursuant to paragraphs (4)(a) and (c), and include the Lake Okeechobee Watershed Construction Project and the Lake Okeechobee Watershed Research and Water Quality Monitoring Program. The plan shall consider and build upon a review and analysis of the performance of projects constructed during Phase I and Phase II of the Lake Okeechobee Watershed Construction Project, pursuant to subparagraph 1.; relevant information resulting from the Lake Okeechobee Basin Management Action Plan, pursuant to paragraph (b); relevant information resulting from the Lake Okeechobee Watershed Research and Water Quality Monitoring Program, pursuant to subparagraph 2.; relevant information resulting from the Lake Okeechobee Exotic Species Control Program, pursuant to paragraph (c); and relevant information resulting from the Lake Okeechobee Internal Phosphorus Management Program, pursuant to paragraph (d).

1. Lake Okeechobee Watershed Construction Project.—To improve the hydrology and water quality of Lake Okeechobee and downstream receiving waters, including the Caloosahatchee and St. Lucie Rivers and their estuaries, the district, in cooperation with the other coordinating agencies, shall design and construct the Lake Okeechobee Watershed Construction Project. The project shall include:

a. Phase I.—Phase I of the Lake Okeechobee Watershed Construction Project shall consist of a series of project features consistent with the recommendations of the South Florida Ecosystem Restoration Working Group's Lake Okeechobee Action Plan. Priority basins for such projects include S-191, S-154, and Pools D and E in the Lower Kissimmee River. To obtain phosphorus load reductions to Lake Okeechobee as soon as possible, the following actions shall be implemented:

(I) The district shall serve as a full partner with the Corps of Engineers in the design and construction of the Grassy Island Ranch and New Palm Dairy stormwater treatment facilities as components of the Lake Okeechobee Water Retention/Phosphorus Removal Critical Project. The Corps of Engineers shall have the lead in design and construction of these facilities. Should delays be encountered in the implementation of either of these facilities, the district shall notify the department and recommend corrective actions.

(II) The district shall obtain permits and complete construction of two of the isolated wetland restoration projects that are part of the Lake Okeechobee Water Retention/Phosphorus Removal Critical Project. The additional isolated wetland projects included in this critical project shall further reduce phosphorus loading to Lake Okeechobee.

(III) The district shall work with the Corps of Engineers to expedite initiation of the design process for the Taylor Creek/Nubbins Slough Reservoir Assisted Stormwater Treatment Area, a project component of the Comprehensive Everglades Restoration Plan. The district shall propose to the Corps of Engineers that the district take the lead in the design and construction of the Reservoir Assisted Stormwater Treatment Area and receive credit towards the local share of the total cost of the Comprehensive Everglades Restoration Plan.

b. Phase II technical plan and construction.—The district, in cooperation with the other coordinating agencies, shall develop a detailed technical plan for Phase II of the Lake Okeechobee Watershed Construction Project which provides the basis for the Lake Okeechobee Basin Management Action Plan adopted by the department pursuant to s. 403.067. The detailed technical plan shall include measures for the improvement of

the quality, quantity, timing, and distribution of water in the northern Everglades ecosystem, including the Lake Okeechobee watershed and the estuaries, and for facilitating the achievement of water quality standards. Use of cost-effective biologically based, hybrid wetland/chemical and other innovative nutrient control technologies shall be incorporated in the plan where appropriate. The detailed technical plan shall also include a Process Development and Engineering component to finalize the detail and design of Phase II projects and identify additional measures needed to increase the certainty that the overall objectives for improving water quality and quantity can be met. Based on information and recommendations from the Process Development and Engineering component, the Phase II detailed technical plan shall be periodically updated. Phase II shall include construction of additional facilities in the priority basins identified in sub-subparagraph a., as well as facilities for other basins in the Lake Okeechobee watershed. The technical plan shall:

(I) Identify Lake Okeechobee Watershed Construction Project facilities designed to contribute to achieving all applicable total maximum daily loads established pursuant to s. 403.067 within the Lake Okeechobee watershed.

(II) Identify the size and location of all such Lake Okeechobee Watershed Construction Project facilities.

(III) Provide a construction schedule for all such Lake Okeechobee Watershed Construction Project facilities, including the sequencing and specific timeframe for construction of each Lake Okeechobee Watershed Construction Project facility.

(IV) Provide a schedule for the acquisition of lands or sufficient interests necessary to achieve the construction schedule.

(V) Provide a detailed schedule of costs associated with the construction schedule.

(VI) Identify, to the maximum extent practicable, impacts on wetlands and state-listed species expected to be associated with construction of such facilities, including potential alternatives to minimize and mitigate such impacts, as appropriate.

(VII) Provide for additional measures, including voluntary water storage and quality improvements on private land, to increase water storage and reduce excess water levels in Lake Okeechobee and to reduce excess discharges to the estuaries.

(VIII) Develop the appropriate water quantity storage goal to achieve the desired Lake Okeechobee range of lake levels and inflow volumes to the Caloosahatchee and St. Lucie estuaries while meeting the other water-related needs of the region, including water supply and flood protection.

(IX) Provide for additional source controls needed to enhance performance of the Lake Okeechobee Watershed Construction Project facilities. Such additional source controls shall be incorporated into the Lake Okeechobee Basin Management Action Plan pursuant to paragraph (b).

c. Evaluation.—Within 5 years after the adoption of the Lake Okeechobee Basin Management Action Plan pursuant to s. 403.067 and every 5 years thereafter, the department, in cooperation with the other coordinating agencies, shall conduct an evaluation of the Lake Okeechobee Watershed Construction Project and identify any further load reductions necessary to achieve compliance with the Lake Okeechobee total maximum daily loads established pursuant to s. 403.067. The district shall identify modifications to facilities of the Lake Okeechobee Watershed Construction Project as appropriate to meet the total maximum daily loads. Modifications to the Lake Okeechobee Watershed Construction Project resulting from this evaluation shall be incorporated into the Lake Okeechobee Basin Management Action Plan and included in the applicable annual progress report submitted pursuant to subsection (6).

d. Coordination and review.—To ensure the timely implementation of the Lake Okeechobee Watershed Construction Project, the design of project facilities shall be coordinated with the department and other

interested parties, including affected local governments, to the maximum extent practicable. Lake Okeechobee Watershed Construction Project facilities shall be reviewed and commented upon by the department before the execution of a construction contract by the district for that facility.

2. Lake Okeechobee Watershed Research and Water Quality Monitoring Program.—The coordinating agencies shall implement a Lake Okeechobee Watershed Research and Water Quality Monitoring Program. Results from the program shall be used by the department, in cooperation with the other coordinating agencies, to make modifications to the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067, as appropriate. The program shall:

a. Evaluate all available existing water quality data concerning total phosphorus in the Lake Okeechobee watershed, develop a water quality baseline to represent existing conditions for total phosphorus, monitor long-term ecological changes, including water quality for total phosphorus, and measure compliance with water quality standards for total phosphorus, including any applicable total maximum daily load for the Lake Okeechobee watershed as established pursuant to s. 403.067. Beginning March 1, 2020, and every 5 years thereafter, the department shall reevaluate water quality and quantity data to ensure that the appropriate projects are being designated and incorporated into the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067. The district shall implement a total phosphorus monitoring program at appropriate structures owned or operated by the district and within the Lake Okeechobee watershed.

b. Develop a Lake Okeechobee water quality model that reasonably represents the phosphorus dynamics of Lake Okeechobee and incorporates an uncertainty analysis associated with model predictions.

c. Determine the relative contribution of phosphorus from all identifiable sources and all primary and secondary land uses.

d. Conduct an assessment of the sources of phosphorus from the Upper Kissimmee Chain of Lakes and Lake Istokpoga and their relative contribution to the water quality of Lake Okeechobee. The results of this assessment shall be used by the coordinating agencies as part of the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067 to develop interim measures, best management practices, or regulations, as applicable.

e. Assess current water management practices within the Lake Okeechobee watershed and develop recommendations for structural and operational improvements. Such recommendations shall balance water supply, flood control, estuarine salinity, maintenance of a healthy lake littoral zone, and water quality considerations.

f. Evaluate the feasibility of alternative nutrient reduction technologies, including sediment traps, canal and ditch maintenance, fish production or other aquaculture, bioenergy conversion processes, and algal or other biological treatment technologies and include any alternative nutrient reduction technologies determined to be feasible in the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067.

g. Conduct an assessment of the water volumes and timing from the Lake Okeechobee watershed and their relative contribution to the water level changes in Lake Okeechobee and to the timing and volume of water delivered to the estuaries.

(b) *Lake Okeechobee Basin Management Action Plan.*—The Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067 shall be the watershed phosphorus control component for Lake Okeechobee. The Lake Okeechobee Basin Management Action Plan shall be a multifaceted approach designed to achieve the total maximum daily load by improving the management of phosphorus sources within the Lake Okeechobee watershed through implementation of regulations and best management practices, continued development and continued implementation of improved best management practices, improvement and restoration of the hydrologic function of natural and managed systems, and use of alternative technologies for

nutrient reduction. As provided in s. 403.067(7)(a)6., the Lake Okeechobee Basin Management Action Plan must include milestones for implementation and water quality improvement, and an associated water quality monitoring component sufficient to evaluate whether reasonable progress in pollutant load reductions is being achieved over time. An assessment of progress toward these milestones shall be conducted every 5 years and shall be provided to the Governor, the President of the Senate, and the Speaker of the House of Representatives. Revisions to the plan shall be made, as appropriate, as a result of each 5-year review. Revisions to the basin management action plan shall be made by the department in cooperation with the basin stakeholders. Revisions to best management practices or other measures must follow the procedures set forth in s. 403.067(7)(c)4. Revised basin management action plans must be adopted pursuant to s. 403.067(7)(a)5. The department shall develop an implementation schedule establishing 5-year, 10-year, and 15-year measurable milestones and targets to achieve the total maximum daily load no more than 20 years after adoption of the plan. The initial implementation schedule shall be used to provide guidance for planning and funding purposes and is exempt from chapter 120. Upon the first 5-year review, the implementation schedule shall be adopted as part of the plan. If achieving the total maximum daily load within 20 years is not practicable, the implementation schedule must contain an explanation of the constraints that prevent achievement of the total maximum daily load within 20 years, an estimate of the time needed to achieve the total maximum daily load, and additional 5-year measurable milestones, as necessary. The coordinating agencies shall develop an interagency agreement pursuant to ss. 373.046 and 373.406(5) which is consistent with the department taking the lead on water quality protection measures through the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067; the district taking the lead on hydrologic improvements pursuant to paragraph (a); and the Department of Agriculture and Consumer Services taking the lead on agricultural interim measures, best management practices, and other measures adopted pursuant to s. 403.067. The interagency agreement must specify how best management practices for nonagricultural nonpoint sources are developed and how all best management practices are implemented and verified consistent with s. 403.067 and this section and must address measures to be taken by the coordinating agencies during any best management practice reevaluation performed pursuant to subparagraphs 5. and 10. The department shall use best professional judgment in making the initial determination of best management practice effectiveness. The coordinating agencies may develop an intergovernmental agreement with local governments to implement nonagricultural nonpoint source best management practices within their respective geographic boundaries. The coordinating agencies shall facilitate the application of federal programs that offer opportunities for water quality treatment, including preservation, restoration, or creation of wetlands on agricultural lands.

1. Agricultural nonpoint source best management practices, developed in accordance with s. 403.067 and designed to achieve the objectives of the Lake Okeechobee Watershed Protection Program as part of a phased approach of management strategies within the Lake Okeechobee Basin Management Action Plan, shall be implemented on an expedited basis.

2. As provided in s. 403.067, the Department of Agriculture and Consumer Services, in consultation with the department, the district, and affected parties, shall initiate rule development for interim measures, best management practices, conservation plans, nutrient management plans, or other measures necessary for Lake Okeechobee watershed total maximum daily load reduction. The rule shall include thresholds for requiring conservation and nutrient management plans and criteria for the contents of such plans. Development of agricultural nonpoint source best management practices shall initially focus on those priority basins listed in sub-subparagraph (a)1.a. The Department of Agriculture and Consumer Services, in consultation with the department, the district, and affected parties, shall conduct an ongoing program for improvement of existing and development of new agricultural nonpoint source interim measures and best management practices. The Department of Agriculture and Consumer Services shall adopt such practices by rule. The Department of Agriculture and Consumer Services shall work with the University of Florida Institute of Food and Agriculture

Sciences to review and, where appropriate, develop revised nutrient application rates for all agricultural soil amendments in the watershed.

3. As provided in s. 403.067, where agricultural nonpoint source best management practices or interim measures have been adopted by rule of the Department of Agriculture and Consumer Services, the owner or operator of an agricultural nonpoint source addressed by such rule shall either implement interim measures or best management practices or demonstrate compliance with state water quality standards addressed by the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067 by conducting monitoring prescribed by the department or the district. Owners or operators of agricultural nonpoint sources who implement interim measures or best management practices adopted by rule of the Department of Agriculture and Consumer Services shall be subject to s. 403.067.

4. The district or department shall conduct monitoring at representative sites to verify the effectiveness of agricultural nonpoint source best management practices.

5. Where water quality problems are detected for agricultural nonpoint sources despite the appropriate implementation of adopted best management practices, a reevaluation of the best management practices shall be conducted pursuant to s. 403.067(7)(c)4. If the reevaluation determines that the best management practices or other measures require modification, the rule shall be revised to require implementation of the modified practice within a reasonable period as specified in the rule.

6. As provided in s. 403.067, nonagricultural nonpoint source best management practices, developed in accordance with s. 403.067 and designed to achieve the objectives of the Lake Okeechobee Watershed Protection Program as part of a phased approach of management strategies within the Lake Okeechobee Basin Management Action Plan, shall be implemented on an expedited basis.

7. The department and the district are directed to work with the University of Florida Institute of Food and Agricultural Sciences to develop appropriate nutrient application rates for all nonagricultural soil amendments in the watershed. As provided in s. 403.067, the department, in consultation with the district and affected parties, shall develop nonagricultural nonpoint source interim measures, best management practices, or other measures necessary for Lake Okeechobee watershed total maximum daily load reduction. Development of nonagricultural nonpoint source best management practices shall initially focus on those priority basins listed in sub-subparagraph (a)1.a. The department, the district, and affected parties shall conduct an ongoing program for improvement of existing and development of new interim measures and best management practices. The department or the district shall adopt such practices by rule.

8. Where nonagricultural nonpoint source best management practices or interim measures have been developed by the department and adopted by the district, the owner or operator of a nonagricultural nonpoint source shall implement interim measures or best management practices and be subject to s. 403.067.

9. As provided in s. 403.067, the district or the department shall conduct monitoring at representative sites to verify the effectiveness of nonagricultural nonpoint source best management practices.

10. Where water quality problems are detected for nonagricultural nonpoint sources despite the appropriate implementation of adopted best management practices, a reevaluation of the best management practices shall be conducted pursuant to s. 403.067(7)(c)4. If the reevaluation determines that the best management practices or other measures require modification, the rule shall be revised to require implementation of the modified practice within a reasonable time period as specified in the rule.

11. Subparagraphs 2. and 7. do not preclude the department or the district from requiring compliance with water quality standards or with current best management practices requirements set forth in any applicable regulatory program authorized by law for the purpose of protecting water quality. Subparagraphs 2. and 7. are

applicable only to the extent that they do not conflict with any rules adopted by the department that are necessary to maintain a federally delegated or approved program.

12. The program of agricultural best management practices set forth in the Everglades Program of the district meets the requirements of this paragraph and s. 403.067(7) for the Lake Okeechobee watershed. An entity in compliance with the best management practices set forth in the Everglades Program of the district may elect to use that permit in lieu of the requirements of this paragraph. The provisions of subparagraph 5. apply to this subparagraph. This subparagraph does not alter any requirement of s. 373.4592.

13. The Department of Agriculture and Consumer Services, in cooperation with the department and the district, shall provide technical and financial assistance for implementation of agricultural best management practices, subject to the availability of funds. The department and district shall provide technical and financial assistance for implementation of nonagricultural nonpoint source best management practices, subject to the availability of funds.

14. Projects that reduce the phosphorus load originating from domestic wastewater systems within the Lake Okeechobee watershed shall be given funding priority in the department's revolving loan program under s. 403.1835. The department shall coordinate and provide assistance to those local governments seeking financial assistance for such priority projects.

15. Projects that make use of private lands, or lands held in trust for Indian tribes, to reduce nutrient loadings or concentrations within a basin by one or more of the following methods: restoring the natural hydrology of the basin, restoring wildlife habitat or impacted wetlands, reducing peak flows after storm events, increasing aquifer recharge, or protecting range and timberland from conversion to development, are eligible for grants available under this section from the coordinating agencies. For projects of otherwise equal priority, special funding priority will be given to those projects that make best use of the methods outlined above that involve public-private partnerships or that obtain federal match money. Preference ranking above the special funding priority will be given to projects located in a rural area of opportunity designated by the Governor. Grant applications may be submitted by any person or tribal entity, and eligible projects may include, but are not limited to, the purchase of conservation and flowage easements, hydrologic restoration of wetlands, creating treatment wetlands, development of a management plan for natural resources, and financial support to implement a management plan.

16. The department shall require all entities disposing of domestic wastewater biosolids within the Lake Okeechobee watershed and the remaining areas of Okeechobee, Glades, and Hendry Counties to develop and submit to the department an agricultural use plan that limits applications based upon phosphorus loading consistent with the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067. The department may not authorize the disposal of domestic wastewater biosolids within the Lake Okeechobee watershed unless the applicant can affirmatively demonstrate that the phosphorus in the biosolids will not add to phosphorus loadings in Lake Okeechobee or its tributaries. This demonstration shall be based on achieving a net balance between phosphorus imports relative to exports on the permitted application site. Exports shall include only phosphorus removed from the Lake Okeechobee watershed through products generated on the permitted application site. This prohibition does not apply to Class AA biosolids that are marketed and distributed as fertilizer products in accordance with department rule.

17. Private and government-owned utilities within Monroe, Miami-Dade, Broward, Palm Beach, Martin, St. Lucie, Indian River, Okeechobee, Highlands, Hendry, and Glades Counties that dispose of wastewater biosolids sludge from utility operations and septic removal by land spreading in the Lake Okeechobee watershed may use a line item on local sewer rates to cover wastewater biosolids treatment and disposal if such disposal and treatment is done by approved alternative treatment methodology at a facility located within the areas designated by the Governor as rural areas of opportunity pursuant to s. 288.0656. This additional line item is an

environmental protection disposal fee above the present sewer rate and may not be considered a part of the present sewer rate to customers, notwithstanding provisions to the contrary in chapter 367. The fee shall be established by the county commission or its designated assignee in the county in which the alternative method treatment facility is located. The fee shall be calculated to be no higher than that necessary to recover the facility's prudent cost of providing the service. Upon request by an affected county commission, the Florida Public Service Commission will provide assistance in establishing the fee. Further, for utilities and utility authorities that use the additional line item environmental protection disposal fee, such fee may not be considered a rate increase under the rules of the Public Service Commission and shall be exempt from such rules. Utilities using this section may immediately include in their sewer invoicing the new environmental protection disposal fee. Proceeds from this environmental protection disposal fee shall be used for treatment and disposal of wastewater biosolids, including any treatment technology that helps reduce the volume of biosolids that require final disposal, but such proceeds may not be used for transportation or shipment costs for disposal or any costs relating to the land application of biosolids in the Lake Okeechobee watershed.

18. No less frequently than once every 3 years, the Florida Public Service Commission or the county commission through the services of an independent auditor shall perform a financial audit of all facilities receiving compensation from an environmental protection disposal fee. The Florida Public Service Commission or the county commission through the services of an independent auditor shall also perform an audit of the methodology used in establishing the environmental protection disposal fee. The Florida Public Service Commission or the county commission shall, within 120 days after completion of an audit, file the audit report with the President of the Senate and the Speaker of the House of Representatives and shall provide copies to the county commissions of the counties set forth in subparagraph 17. The books and records of any facilities receiving compensation from an environmental protection disposal fee shall be open to the Florida Public Service Commission and the Auditor General for review upon request.

19. The Department of Health shall require all entities disposing of septage within the Lake Okeechobee watershed to develop and submit to that agency an agricultural use plan that limits applications based upon phosphorus loading consistent with the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067.

20. The Department of Agriculture and Consumer Services shall initiate rulemaking requiring entities within the Lake Okeechobee watershed which land-apply animal manure to develop resource management system level conservation plans, according to United States Department of Agriculture criteria, which limit such application. Such rules must include criteria and thresholds for the requirement to develop a conservation or nutrient management plan, requirements for plan approval, site inspection requirements, and recordkeeping requirements.

21. The district shall revise chapter 40E-61, Florida Administrative Code, to be consistent with this section and s. 403.067; provide for a monitoring program for nonpoint source dischargers required to monitor water quality by s. 403.067; and provide for the results of such monitoring to be reported to the coordinating agencies.

(c) *Lake Okeechobee Exotic Species Control Program.*—The coordinating agencies shall identify the exotic species that threaten the native flora and fauna within the Lake Okeechobee watershed and develop and implement measures to protect the native flora and fauna.

(d) *Lake Okeechobee Internal Phosphorus Management Program.*—The district, in cooperation with the other coordinating agencies and interested parties, shall evaluate the feasibility of Lake Okeechobee internal phosphorus load removal projects. The evaluation shall be based on technical feasibility, as well as economic considerations, and shall consider all reasonable methods of phosphorus removal. If projects are found to be feasible, the district shall immediately pursue the design, funding, and permitting for implementing such projects.

(e) *Lake Okeechobee Watershed Protection Program implementation.*—The coordinating agencies shall be jointly responsible for implementing the Lake Okeechobee Watershed Protection Program, consistent with the statutory authority and responsibility of each agency. Annual funding priorities shall be jointly established, and the highest priority shall be assigned to programs and projects that address sources that have the highest relative contribution to loading and the greatest potential for reductions needed to meet the total maximum daily loads. In determining funding priorities, the coordinating agencies shall also consider the need for regulatory compliance, the extent to which the program or project is ready to proceed, and the availability of federal matching funds or other nonstate funding, including public-private partnerships. Federal and other nonstate funding shall be maximized to the greatest extent practicable.

(f) *Priorities and implementation schedules.*—The coordinating agencies are authorized and directed to establish priorities and implementation schedules for the achievement of total maximum daily loads, compliance with the requirements of s. 403.067, and compliance with applicable water quality standards within the waters and watersheds subject to this section.

(4) CALOOSAHATCHEE RIVER WATERSHED PROTECTION PROGRAM AND ST. LUCIE RIVER WATERSHED PROTECTION PROGRAM.—A protection program shall be developed and implemented as specified in this subsection. To protect and restore surface water resources, the program shall address the reduction of pollutant loadings, restoration of natural hydrology, and compliance with applicable state water quality standards. The program shall be achieved through a phased program of implementation. In addition, pollutant load reductions based upon adopted total maximum daily loads established in accordance with s. 403.067 shall serve as a program objective. In the development and administration of the program, the coordinating agencies shall maximize opportunities provided by federal and local government cost-sharing programs and opportunities for partnerships with the private sector and local government. The program shall include a goal for salinity envelopes and freshwater inflow targets for the estuaries based upon existing research and documentation. The goal may be revised as new information is available. This goal shall seek to reduce the frequency and duration of undesirable salinity ranges while meeting the other water-related needs of the region, including water supply and flood protection, while recognizing the extent to which water inflows are within the control and jurisdiction of the district.

(a) *Caloosahatchee River Watershed Protection Plan.*—The district, in cooperation with the other coordinating agencies, Lee County, and affected counties and municipalities, shall complete a River Watershed Protection Plan in accordance with this subsection. The Caloosahatchee River Watershed Protection Plan shall identify the geographic extent of the watershed, be coordinated as needed with the plans developed pursuant to paragraph (3)(a) and paragraph (c) of this subsection, and include the Caloosahatchee River Watershed Construction Project and the Caloosahatchee River Watershed Research and Water Quality Monitoring Program.

1. Caloosahatchee River Watershed Construction Project.—To improve the hydrology, water quality, and aquatic habitats within the watershed, the district shall, no later than January 1, 2012, plan, design, and construct the initial phase of the Watershed Construction Project. In doing so, the district shall:

a. Develop and designate the facilities to be constructed to achieve stated goals and objectives of the Caloosahatchee River Watershed Protection Plan.

b. Conduct scientific studies that are necessary to support the design of the Caloosahatchee River Watershed Construction Project facilities.

c. Identify the size and location of all such facilities.

d. Provide a construction schedule for all such facilities, including the sequencing and specific timeframe for construction of each facility.

e. Provide a schedule for the acquisition of lands or sufficient interests necessary to achieve the construction schedule.

f. Provide a schedule of costs and benefits associated with each construction project and identify funding sources.

g. To ensure timely implementation, coordinate the design, scheduling, and sequencing of project facilities with the coordinating agencies, Lee County, other affected counties and municipalities, and other affected parties.

2. Caloosahatchee River Watershed Research and Water Quality Monitoring Program.—The district, in cooperation with the other coordinating agencies and local governments, shall implement a Caloosahatchee River Watershed Research and Water Quality Monitoring Program that builds upon the district's existing research program and that is sufficient to carry out, comply with, or assess the plans, programs, and other responsibilities created by this subsection. The program shall also conduct an assessment of the water volumes and timing from Lake Okeechobee and the Caloosahatchee River watershed and their relative contributions to the timing and volume of water delivered to the estuary.

(b) *Caloosahatchee River Watershed Basin Management Action Plans*.—The basin management action plans adopted pursuant to s. 403.067 for the Caloosahatchee River watershed shall be the Caloosahatchee River Watershed Pollutant Control Program. The plans shall be designed to be a multifaceted approach to reducing pollutant loads by improving the management of pollutant sources within the Caloosahatchee River watershed through implementation of regulations and best management practices, development and implementation of improved best management practices, improvement and restoration of the hydrologic function of natural and managed systems, and utilization of alternative technologies for pollutant reduction, such as cost-effective biologically based, hybrid wetland/chemical and other innovative nutrient control technologies. As provided in s. 403.067(7)(a)6., the Caloosahatchee River Watershed Basin Management Action Plans must include milestones for implementation and water quality improvement, and an associated water quality monitoring component sufficient to evaluate whether reasonable progress in pollutant load reductions is being achieved over time. An assessment of progress toward these milestones shall be conducted every 5 years and shall be provided to the Governor, the President of the Senate, and the Speaker of the House of Representatives. Revisions to the plans shall be made, as appropriate, as a result of each 5-year review. Revisions to the basin management action plans shall be made by the department in cooperation with the basin stakeholders. Revisions to best management practices or other measures must follow the procedures set forth in s. 403.067(7)(c)4. Revised basin management action plans must be adopted pursuant to s. 403.067(7)(a)5. The department shall develop an implementation schedule establishing 5-year, 10-year, and 15-year measurable milestones and targets to achieve the total maximum daily load no more than 20 years after adoption of the plan. The initial implementation schedule shall be used to provide guidance for planning and funding purposes and is exempt from chapter 120. Upon the first 5-year review, the implementation schedule shall be adopted as part of the plans. If achieving the total maximum daily load within 20 years is not practicable, the implementation schedule must contain an explanation of the constraints that prevent achievement of the total maximum daily load within 20 years, an estimate of the time needed to achieve the total maximum daily load, and additional 5-year measurable milestones, as necessary. The coordinating agencies shall facilitate the use of federal programs that offer opportunities for water quality treatment, including preservation, restoration, or creation of wetlands on agricultural lands.

1. Nonpoint source best management practices consistent with s. 403.067, designed to achieve the objectives of the Caloosahatchee River Watershed Protection Program, shall be implemented on an expedited basis. The coordinating agencies may develop an intergovernmental agreement with local governments to implement the nonagricultural, nonpoint source best management practices within their respective geographic boundaries.

2. This subsection does not preclude the department or the district from requiring compliance with water quality standards, adopted total maximum daily loads, or current best management practices requirements set forth in any applicable regulatory program authorized by law for the purpose of protecting water quality. This subsection applies only to the extent that it does not conflict with any rules adopted by the department or district which are necessary to maintain a federally delegated or approved program.

3. Projects that make use of private lands, or lands held in trust for Indian tribes, to reduce pollutant loadings or concentrations within a basin, or that reduce the volume of harmful discharges by one or more of the following methods: restoring the natural hydrology of the basin, restoring wildlife habitat or impacted wetlands, reducing peak flows after storm events, or increasing aquifer recharge, are eligible for grants available under this section from the coordinating agencies.

4. The Caloosahatchee River Watershed Basin Management Action Plans shall require assessment of current water management practices within the watershed and shall require development of recommendations for structural, nonstructural, and operational improvements. Such recommendations shall consider and balance water supply, flood control, estuarine salinity, aquatic habitat, and water quality considerations.

5. The department may not authorize the disposal of domestic wastewater biosolids within the Caloosahatchee River watershed unless the applicant can affirmatively demonstrate that the nutrients in the biosolids will not add to nutrient loadings in the watershed. This demonstration shall be based on achieving a net balance between nutrient imports relative to exports on the permitted application site. Exports shall include only nutrients removed from the watershed through products generated on the permitted application site. This prohibition does not apply to Class AA biosolids that are marketed and distributed as fertilizer products in accordance with department rule.

6. The Department of Health shall require all entities disposing of septage within the Caloosahatchee River watershed to develop and submit to that agency an agricultural use plan that limits applications based upon nutrient loading consistent with any basin management action plan adopted pursuant to s. 403.067.

7. The Department of Agriculture and Consumer Services shall require entities within the Caloosahatchee River watershed which land-apply animal manure to develop a resource management system level conservation plan, according to United States Department of Agriculture criteria, which limit such application. Such rules shall include criteria and thresholds for the requirement to develop a conservation or nutrient management plan, requirements for plan approval, site inspection requirements, and recordkeeping requirements.

8. The district shall initiate rulemaking to provide for a monitoring program for nonpoint source dischargers required to monitor water quality pursuant to s. 403.067(7)(b)2.g. or (c)3. The results of such monitoring must be reported to the coordinating agencies.

(c) *St. Lucie River Watershed Protection Plan.*—The district, in cooperation with the other coordinating agencies, Martin County, and affected counties and municipalities shall complete a plan in accordance with this subsection. The St. Lucie River Watershed Protection Plan shall identify the geographic extent of the watershed, be coordinated as needed with the plans developed pursuant to paragraph (3)(a) and paragraph (a) of this subsection, and include the St. Lucie River Watershed Construction Project and St. Lucie River Watershed Research and Water Quality Monitoring Program.

1. St. Lucie River Watershed Construction Project.—To improve the hydrology, water quality, and aquatic habitats within the watershed, the district shall, no later than January 1, 2012, plan, design, and construct the initial phase of the Watershed Construction Project. In doing so, the district shall:

a. Develop and designate the facilities to be constructed to achieve stated goals and objectives of the St. Lucie River Watershed Protection Plan.

b. Identify the size and location of all such facilities.

c. Provide a construction schedule for all such facilities, including the sequencing and specific timeframe for construction of each facility.

d. Provide a schedule for the acquisition of lands or sufficient interests necessary to achieve the construction schedule.

e. Provide a schedule of costs and benefits associated with each construction project and identify funding sources.

f. To ensure timely implementation, coordinate the design, scheduling, and sequencing of project facilities with the coordinating agencies, Martin County, St. Lucie County, other interested parties, and other affected local governments.

2. St. Lucie River Watershed Research and Water Quality Monitoring Program.—The district, in cooperation with the other coordinating agencies and local governments, shall establish a St. Lucie River Watershed Research and Water Quality Monitoring Program that builds upon the district's existing research program and that is sufficient to carry out, comply with, or assess the plans, programs, and other responsibilities created by this subsection. The district shall also conduct an assessment of the water volumes and timing from Lake Okeechobee and the St. Lucie River watershed and their relative contributions to the timing and volume of water delivered to the estuary.

(d) *St. Lucie River Watershed Basin Management Action Plan.*—The basin management action plan for the St. Lucie River watershed adopted pursuant to s. 403.067 shall be the St. Lucie River Watershed Pollutant Control Program and shall be designed to be a multifaceted approach to reducing pollutant loads by improving the management of pollutant sources within the St. Lucie River watershed through implementation of regulations and best management practices, development and implementation of improved best management practices, improvement and restoration of the hydrologic function of natural and managed systems, and use of alternative technologies for pollutant reduction, such as cost-effective biologically based, hybrid wetland/chemical and other innovative nutrient control technologies. As provided in s. 403.067(7)(a)6., the St. Lucie River Watershed Basin Management Action Plan must include milestones for implementation and water quality improvement, and an associated water quality monitoring component sufficient to evaluate whether reasonable progress in pollutant load reductions is being achieved over time. An assessment of progress toward these milestones shall be conducted every 5 years and shall be provided to the Governor, the President of the Senate, and the Speaker of the House of Representatives. Revisions to the plan shall be made, as appropriate, as a result of each 5-year review. Revisions to the basin management action plan shall be made by the department in cooperation with the basin stakeholders. Revisions to best management practices or other measures must follow the procedures set forth in s. 403.067(7)(c)4. Revised basin management action plans must be adopted pursuant to s. 403.067(7)(a)5. The department shall develop an implementation schedule establishing 5-year, 10-year, and 15-year measurable milestones and targets to achieve the total maximum daily load no more than 20 years after adoption of the plan. The initial implementation schedule shall be used to provide guidance for planning and funding purposes and is exempt from chapter 120. Upon the first 5-year review, the implementation schedule shall be adopted as part of the plan. If achieving the total maximum daily load within 20 years is not practicable, the implementation schedule must contain an explanation of the constraints that prevent achievement of the total maximum daily load within 20 years, an estimate of the time needed to achieve the total maximum daily load, and additional 5-year measurable milestones, as necessary. The coordinating agencies shall facilitate the use of federal programs that offer opportunities for water quality treatment, including preservation, restoration, or creation of wetlands on agricultural lands.

1. Nonpoint source best management practices consistent with s. 403.067, designed to achieve the objectives of the St. Lucie River Watershed Protection Program, shall be implemented on an expedited basis. The

coordinating agencies may develop an intergovernmental agreement with local governments to implement the nonagricultural nonpoint source best management practices within their respective geographic boundaries.

2. This subsection does not preclude the department or the district from requiring compliance with water quality standards, adopted total maximum daily loads, or current best management practices requirements set forth in any applicable regulatory program authorized by law for the purpose of protecting water quality. This subsection applies only to the extent that it does not conflict with any rules adopted by the department or district which are necessary to maintain a federally delegated or approved program.

3. Projects that make use of private lands, or lands held in trust for Indian tribes, to reduce pollutant loadings or concentrations within a basin, or that reduce the volume of harmful discharges by one or more of the following methods: restoring the natural hydrology of the basin, restoring wildlife habitat or impacted wetlands, reducing peak flows after storm events, or increasing aquifer recharge, are eligible for grants available under this section from the coordinating agencies.

4. The St. Lucie River Watershed Basin Management Action Plan shall require assessment of current water management practices within the watershed and shall require development of recommendations for structural, nonstructural, and operational improvements. Such recommendations shall consider and balance water supply, flood control, estuarine salinity, aquatic habitat, and water quality considerations.

5. The department may not authorize the disposal of domestic wastewater biosolids within the St. Lucie River watershed unless the applicant can affirmatively demonstrate that the nutrients in the biosolids will not add to nutrient loadings in the watershed. This demonstration shall be based on achieving a net balance between nutrient imports relative to exports on the permitted application site. Exports shall include only nutrients removed from the St. Lucie River watershed through products generated on the permitted application site. This prohibition does not apply to Class AA biosolids that are marketed and distributed as fertilizer products in accordance with department rule.

6. The Department of Health shall require all entities disposing of septage within the St. Lucie River watershed to develop and submit to that agency an agricultural use plan that limits applications based upon nutrient loading consistent with any basin management action plan adopted pursuant to s. 403.067.

7. The Department of Agriculture and Consumer Services shall initiate rulemaking requiring entities within the St. Lucie River watershed which land-apply animal manure to develop a resource management system level conservation plan, according to United States Department of Agriculture criteria, which limit such application. Such rules shall include criteria and thresholds for the requirement to develop a conservation or nutrient management plan, requirements for plan approval, site inspection requirements, and recordkeeping requirements.

8. The district shall initiate rulemaking to provide for a monitoring program for nonpoint source dischargers required to monitor water quality pursuant to s. 403.067(7)(b)2.g. or (c)3. The results of such monitoring must be reported to the coordinating agencies.

(e) *River Watershed Protection Plan implementation.*—The coordinating agencies shall be jointly responsible for implementing the River Watershed Protection Plans, consistent with the statutory authority and responsibility of each agency. Annual funding priorities shall be jointly established, and the highest priority shall be assigned to programs and projects that have the greatest potential for achieving the goals and objectives of the plans. In determining funding priorities, the coordinating agencies shall also consider the need for regulatory compliance, the extent to which the program or project is ready to proceed, and the availability of federal or local government matching funds. Federal and other nonstate funding shall be maximized to the greatest extent practicable.

(f) *Evaluation.*—Beginning March 1, 2020, and every 5 years thereafter, concurrent with the updates of the basin management action plans adopted pursuant to s. 403.067, the department, in cooperation with the other coordinating agencies, shall conduct an evaluation of any pollutant load reduction goals, as well as any other specific objectives and goals, as stated in the River Watershed Protection Programs. The district shall identify modifications to facilities of the River Watershed Construction Projects, as appropriate, or any other elements of the River Watershed Protection Programs. The evaluation shall be included in the annual progress report submitted pursuant to this section.

(g) *Priorities and implementation schedules.*—The coordinating agencies are authorized and directed to establish priorities and implementation schedules for the achievement of total maximum daily loads, the requirements of s. 403.067, and compliance with applicable water quality standards within the waters and watersheds subject to this section.

(5) ADOPTION AND IMPLEMENTATION OF TOTAL MAXIMUM DAILY LOADS AND DEVELOPMENT OF BASIN MANAGEMENT ACTION PLANS.—The department is directed to expedite development and adoption of total maximum daily loads for the Caloosahatchee River and estuary. The department is further directed to propose for final agency action total maximum daily loads for nutrients in the tidal portions of the Caloosahatchee River and estuary. The department shall initiate development of basin management action plans for Lake Okeechobee, the Caloosahatchee River watershed and estuary, and the St. Lucie River watershed and estuary as provided in s. 403.067 as follows:

(a) Basin management action plans shall be developed as soon as practicable as determined necessary by the department to achieve the total maximum daily loads established for the Lake Okeechobee watershed and the estuaries.

(b) The Phase II technical plan development pursuant to paragraph (3)(a), and the River Watershed Protection Plans developed pursuant to paragraphs (4)(a) and (c), shall provide the basis for basin management action plans developed by the department.

(c) As determined necessary by the department to achieve the total maximum daily loads, additional or modified projects or programs that complement those in the legislatively ratified plans may be included during the development of the basin management action plan.

(d) As provided in s. 403.067, management strategies and pollution reduction requirements set forth in a basin management action plan subject to permitting by the department under subsection (7) must be completed pursuant to the schedule set forth in the basin management action plan, as amended. The implementation schedule may extend beyond the 5-year permit term.

(e) As provided in s. 403.067, management strategies and pollution reduction requirements set forth in a basin management action plan for a specific pollutant of concern are not subject to challenge under chapter 120 at the time they are incorporated, in an identical form, into a department or district issued permit or a permit modification issued in accordance with subsection (7).

(6) ANNUAL PROGRESS REPORT.—Each March 1, the district, in cooperation with the other coordinating agencies, shall report on implementation of this section as part of the consolidated annual report required in s. 373.036(7). The annual report shall include a summary of the conditions of the hydrology, water quality, and aquatic habitat in the northern Everglades based on the results of the Research and Water Quality Monitoring Programs, the status of the Lake Okeechobee Watershed Construction Project, the status of the Caloosahatchee River Watershed Construction Project, and the status of the St. Lucie River Watershed Construction Project. In addition, the report shall contain an annual accounting of the expenditure of funds from the Save Our Everglades Trust Fund. At a minimum, the annual report shall provide detail by program and plan, including specific information concerning the amount and use of funds from federal, state, or local government sources. In

detailing the use of these funds, the district shall indicate those designated to meet requirements for matching funds. The district shall prepare the report in cooperation with the other coordinating agencies and affected local governments. The department shall report on the status of the Lake Okeechobee Basin Management Action Plan, the Caloosahatchee River Watershed Basin Management Action Plan, and the St. Lucie River Watershed Basin Management Action Plan. The Department of Agriculture and Consumer Services shall report on the status of the implementation of the agricultural nonpoint source best management practices, including an implementation assurance report summarizing survey responses and response rates, site inspections, and other methods used to verify implementation of and compliance with best management practices in the Lake Okeechobee, Caloosahatchee River, and St. Lucie River watersheds.

(7) LAKE OKEECHOBEE PROTECTION PERMITS.—

(a) The Legislature finds that the Lake Okeechobee Watershed Protection Program will benefit Lake Okeechobee and downstream receiving waters and is in the public interest. The Lake Okeechobee Watershed Construction Project and structures discharging into or from Lake Okeechobee shall be constructed, operated, and maintained in accordance with this section.

(b) Permits obtained pursuant to this section are in lieu of all other permits under this chapter or chapter 403, except those issued under s. 403.0885, if applicable. Additional permits are not required for the Lake Okeechobee Watershed Construction Project, or structures discharging into or from Lake Okeechobee, if such project or structures are permitted under this section. Construction activities related to implementation of the Lake Okeechobee Watershed Construction Project may be initiated before final agency action, or notice of intended agency action, on any permit from the department under this section.

(c)1. Owners or operators of existing structures which discharge into or from Lake Okeechobee that were subject to Department Consent Orders 91-0694, 91-0705, 91-0706, 91-0707, and RT50-205564 and that are subject to s. 373.4592(4)(a) do not require a permit under this section and shall be governed by permits issued under ss. 373.413 and 373.416 and the Lake Okeechobee Basin Management Action Plan adopted pursuant to s. 403.067.

2. For the purposes of this paragraph, owners and operators of existing structures which are subject to s. 373.4592(4)(a) and which discharge into or from Lake Okeechobee shall be deemed in compliance with this paragraph if they are in full compliance with the conditions of permits under chapter 40E-63, Florida Administrative Code.

3. By January 1, 2017, the district shall submit to the department a complete application for a permit modification to the Lake Okeechobee structure permits to incorporate proposed changes necessary to ensure that discharges through the structures covered by this permit are consistent with the basin management action plan adopted pursuant to s. 403.067.

(d) The department shall require permits for district regional projects that are part of the Lake Okeechobee Watershed Construction Project. However, projects that qualify as exempt pursuant to s. 373.406 do not require permits under this section. Such permits shall be issued for a term of 5 years upon the demonstration of reasonable assurances that:

1. District regional projects that are part of the Lake Okeechobee Watershed Construction Project shall achieve the design objectives for phosphorus required in subparagraph (3)(a)1.;

2. For water quality standards other than phosphorus, the quality of water discharged from the facility is of equal or better quality than the inflows;

3. Discharges from the facility do not pose a serious danger to public health, safety, or welfare; and

4. Any impacts on wetlands or state-listed species resulting from implementation of that facility of the Lake Okeechobee Construction Project are minimized and mitigated, as appropriate.

(e) At least 60 days before the expiration of any permit issued under this section, the permittee may apply for a renewal thereof for a period of 5 years.

(f) Permits issued under this section may include any standard conditions provided by department rule which are appropriate and consistent with this section.

(g) Permits issued under this section may be modified, as appropriate, upon review and approval by the department.

(8) RESTRICTIONS ON WATER DIVERSIONS.—The South Florida Water Management District shall not divert waters to the St. Lucie River, the Indian River estuary, the Caloosahatchee River or its estuary, or the Everglades National Park, in such a way that the state water quality standards are violated, that the nutrients in such diverted waters adversely affect indigenous vegetation communities or wildlife, or that fresh waters diverted to the St. Lucie River or the Caloosahatchee or Indian River estuaries adversely affect the estuarine vegetation or wildlife, unless the receiving waters will biologically benefit by the diversion. However, diversion is permitted when an emergency is declared by the water management district, if the Secretary of Environmental Protection concurs.

(9) PRESERVATION OF PROVISIONS RELATING TO THE EVERGLADES.—Nothing in this section shall be construed to modify any provision of s. 373.4592.

(10) RIGHTS OF SEMINOLE TRIBE OF FLORIDA.—Nothing in this section is intended to diminish or alter the governmental authority and powers of the Seminole Tribe of Florida, or diminish or alter the rights of that tribe, including, but not limited to, rights under the water rights compact among the Seminole Tribe of Florida, the state, and the South Florida Water Management District as enacted by Pub. L. No. 100-228, 101 Stat. 1556, and chapter 87-292, Laws of Florida, and codified in s. 285.165, and rights under any other agreement between the Seminole Tribe of Florida and the state or its agencies. No land of the Seminole Tribe of Florida shall be used for water storage or stormwater treatment without the consent of the tribe.

(11) RELATIONSHIP TO STATE WATER QUALITY STANDARDS.—Nothing in this section shall be construed to modify any existing state water quality standard or to modify the provisions of s. 403.067(6) and (7)(a).

(12) RULES.—The governing board of the district is authorized to adopt rules pursuant to ss. 120.536(1) and 120.54 to implement the provisions of this section.

(13) PRESERVATION OF AUTHORITY.—Nothing in this section shall be construed to restrict the authority otherwise granted to agencies pursuant to this chapter and chapter 403, and provisions of this section shall be deemed supplemental to the authority granted to agencies pursuant to this chapter and chapter 403.

History.—s. 6, ch. 87-97; s. 274, ch. 94-356; s. 1011, ch. 95-148; s. 189, ch. 99-245; s. 1, ch. 2000-130; s. 6, ch. 2001-172; s. 1, ch. 2001-193; s. 3, ch. 2002-165; s. 42, ch. 2002-296; s. 1, ch. 2005-29; s. 14, ch. 2005-36; s. 7, ch. 2005-166; s. 14, ch. 2005-291; s. 4, ch. 2007-191; s. 3, ch. 2007-253; s. 87, ch. 2008-4; s. 1, ch. 2013-146; s. 39, ch. 2014-218; s. 15, ch. 2016-1.

403.0855 Biosolids management.—

(1) The Legislature finds that it is in the best interest of this state to regulate biosolids management in order to minimize the migration of nutrients that impair water bodies. The Legislature further finds that permitting according to site-specific application conditions, an increased inspection rate, groundwater and surface water monitoring protocols, and nutrient management research will improve biosolids management and assist in protecting this state's water resources and water quality.

(2) The department shall adopt rules for biosolids management. Rules adopted by the department pursuant to this section may not take effect until ratified by the Legislature.

(3) For a new land application site permit or a permit renewal issued after July 1, 2020, the permittee of a biosolids land application site shall:

(a) Ensure a minimum unsaturated soil depth of 2 feet between the depth of biosolids placement and the water table level at the time the Class A or Class B biosolids are applied to the soil. Biosolids may not be applied on soils that have a seasonal high-water table less than 6 inches from the soil surface or within 6 inches of the intended depth of biosolids placement, unless a department-approved nutrient management plan and water quality monitoring plan provide reasonable assurances that the land application of biosolids at the site will not cause or contribute to a violation of the state's surface water quality standards or groundwater standards. As used in this subsection, the term "seasonal high water" means the elevation to which the ground and surface water may be expected to rise due to a normal wet season.

(b) Be enrolled in the Department of Agriculture and Consumer Services best management practices program or be within an agricultural operation enrolled in the program for the applicable commodity type.

(4) All permits shall comply with the requirements of subsection (3) by July 1, 2022.

(5) New or renewed biosolids land application site or facility permits issued after July 1, 2020, must comply with this section and include a permit condition that requires the permit to be reopened to insert a compliance date of no later than 1 year after the effective date of the rules adopted pursuant to subsection (2). All permits must meet the requirements of the rules adopted pursuant to subsection (2) no later than 2 years after the effective date of such rules.

(6) A municipality or county may enforce or extend a local ordinance, regulation, resolution, rule, moratorium, or policy, any of which was adopted before November 1, 2019, relating to the land application of Class A or Class B biosolids until the ordinance, regulation, resolution, rule, moratorium, or policy is repealed by the municipality or county.

History.—s. 16, ch. 2020-150.

Department of Environmental Protection Rules.

The DEP regulates biosolids via Rule Chapter 62-640, F.A.C. Rule 62-640.100, F.A.C.,

(10) "Class A biosolids" means biosolids that meet the Class A pathogen reduction requirements of paragraph 62-640.600(1)(a), F.A.C., the vector attraction reduction requirements of paragraph 62-640.600(2)(a), F.A.C., and the parameter concentrations of paragraph 62-640.700(5)(a), F.A.C.

(11) "Class AA biosolids" means biosolids that meet the Class AA pathogen reduction requirements of paragraph 62-640.600(1)(a), F.A.C., the vector attraction reduction requirements of paragraph 62-640.600(2)(b), F.A.C., and the parameter concentrations of paragraphs 62-640.700(5)(a) and (b), F.A.C.

(12) "Class B biosolids" means biosolids that meet the Class B pathogen reduction requirements of paragraph 62-640.600(1)(b), F.A.C., the vector attraction reduction requirements of paragraph 62-640.600(2)(a), F.A.C., and the parameter concentrations of paragraph 62-640.700(5)(a), F.A.C.

Appendix J. Select Annotated Bibliography, by Topic

Alternative Treatments

Biosolids Technical Advisory Committee. (2019). (DEP) Biosolids Technical Advisory Committee Recommendations.

The Biosolids TAC recommends established application rates based on site specifics, percent of water extractable phosphorus, and a range of categorized risk sites to minimize migration of nutrients and prevent impairment to waterbodies. The TAC further recommends increased inspection rates, site specific water monitoring protocols, and research on nutrient run-off based on varying conditions. Innovative technology pilot projects are also recommended.

Collivignarelli, M.C., et al. (2019). Biosolids: What are the Different Types of Reuse? Journal of Cleaner Production (238).

This article investigates the role of WWTPs as an important part of circular sustainability if re-oriented to function as water resource recovery facilities (WRRFs). Possible alternatives are explored such as soil amendment/fertilizer both in agriculture and for interventions on abandoned mine sites, and on engineering fields, in partial or total substation of virgin materials. The reuse of BS as adsorbent materials and as a source of phosphorus is also discussed. Benefits of land application include improving soil structure, decreasing bulk density, increasing soil porosity, increasing soil moisture retention, increasing hydraulic conductivity, and increasing crop yield. No agreement on effects of land application. Researchers mainly refer to raising levels of persistent toxins, biodiversity-reduction, and greenhouse gas emissions. Other issues related to social acceptance, heavy metals, human pathogens, and organic contaminants. Many studies show highlight the potential use of biosolids in road construction through direct application, mixing with other resources, or embankment soil for plants. Another study mentions the use of biosolids in brick production if proportion of biosolids remain below 30%. Some sectors of public opinion are against this practice due to unfamiliarity and lack of information. Similarly, biosolids can be used for the production of lightweight aggregates (LWAs), cement, supplementary cementitious materials, and alternative fuels. Issues with air emissions reported when biosolids used as alternative fuels. Overall, these practices decrease resource demand used by different sectors and lower human health impacts as well as operating costs.

East Central Florida Regional Planning Council & Treasure Coast Regional Planning Council. (2015). Impediments to Implementation of the Indian River Lagoon Basin Management Action Plans. Florida Department of Economic Opportunity.

Regional assessment on IRL and St. Lucie River Estuary BMAPs through direct discussions with and surveys of local government representatives. Impediments include inadequate funding; nutrient loading from muck not being addressed; no incentives for innovative stormwater management; lack of data; unequal treatment of public and private entities, agriculture, and water control districts; and more. Total of 15 impediments to achieving TMDLs. Other concerns about herbicides, insecticides, horticultural chemicals, pharmaceuticals, etc. Recommendations focus on more funding through DEP, matching grant programs, state comprehensive water quality monitoring program as part of overall statewide BMAP program, comprehensive audits of program goals, etc.

Environment Coastal & Offshore. (2018). Cyanobacteria Crises: Governor Scott Issues State of Emergency for Florida Counties. Ecomagazine. Web. https://www.ecomagazine.com/news/policy/cyanobacteria-crisis-governor-scott-issues-state-of-emergency-for-florida-counties

State of emergency issued in Lee and Martin counties as a result of cyanobacteria blooms and public health hazards. 90% of the lake covered. USACE at blame since restoration work is too slow and not funding enough. Discharges delayed. CERP efforts. Biosolids symposium estimates 340,000 tons of biosolids produced (100,000 Class B fertilizers regulated, 100,000 dry tons in landfills, 140,000 dry tons Class AA fertilizers unregulated). Class B and Class AA = 5.5% TN and 2.2% TP. Unknown impacts related to pharmaceuticals, steroids, and bacteria in biosolids. Respiratory issues confirmed from cyanobacteria along with reductions in crop production. Biosolid nutrient application is inefficient. Alternatives include Supercritical Water Oxidation, Advanced Pyrolysis Technology, and Vapor Recompression Distillation for destroying inorganics, converting to energy and biochar, and more efficient extractions of nutrients for easier transportation.

Janicki, P. (2018). Omniprocessor Vapor Recompression. Web. PowerPoint.

2,013 square foot Pilot project capable of processing 10 wet (5 dry) tons/day, producing 100 kW of net electricity, 1,000 gallons/day of re-use water, and 0.5 tons/day of ash. Dairies are associated with surface and groundwater contamination. VRD process capable of 294,000 lbs./day of raw septage. 14,700 lbs./day of dry biosolid produced after heating. Saturated liquid combined with steaming and distillation process to produce 274,900 lbs./day of clean water (94% of start volume/animal drinking water, flush water, or irrigation) and 4,400 lbs./day of ammonia solution (nitrogen-rich fertilizer, pathogen-free, exportable). Also, lower contamination levels. Vapor recompression units produce clean water and ammonia that can be sold. Dry solids can be taken to a power plant that converts to electricity for the grid and further concentrates phosphorus to use locally or ship out of state. VR unit can process 45 GPM, 8% of solids, 21.7 tons of dry solids per day and 7945 tons per year for $8 million and an electric cost of 0.7 cent/gallon with 9 cent/kw-hr power in. a 5 MW steam power plant requires 150 tons of dry fuel per day and 54,750 tons per year to generate $3,940,000 in electric revenue per year, assuming electric sale price of 9 cents/kw-hr with approximately 7 VRD's.

Mason-Renton, S., & Luginaah, I. (2018). Conceptualizing Waste as a Resource: Urban Biosolids Processing in the Rural Landscape. The Canadian Geographer 62(2) 266-281.

The Ontario Ministry for Agriculture, Food, and Rural Affairs (OMAFRA) argues that biosolids should be returned to rural lands for nutrient recycling as the landfill and incinerator are viewed as a dead-end for these valuable nutrients. Literature discusses the value of high energy, nutrient content, phosphate availability, organic carbon, and new technologies that remove contaminants. Public concerns about contaminants are still present, specifically regarding the land application of lesser-treated biosolids. Decisions regarding treatment are dependent on different perspectives and social constructions and are operative across various scales. The notion of sewage waste as out of place in urban areas, but natural to rural areas. Through a case study of a proposed (now operational) biosolids fertilizer processing facility, the Organic Material Recovery Center (OMRC) in the Township of Southgate in rural southwestern Ontario, this research found that the OMRC accepts dewatered biosolids (transported by truck) from municipalities across southern Ontario but does not treat Southgate's waste. The OMRC state several community benefits including providing

affordable nutrients for local farmers, improving soil fertility, and increasing the municipal tax base and local employment opportunities. The public responded with an extended blockade, protests, and a citizen group taking the municipality to court over zoning and siting. Concerns in the study arose over uncertainty surrounding short- and long-term impacts of many chemicals mixed together in wastewater and lack of transparency and communication in regulations, processing, and monitoring of wastewater treatment facilities, fertilizer processing, product composition, and associated risks. Negative past experiences with land-application also hinder appreciation of new controls. Supportive residents highlighted biosolids as valuable nutrient and economic value of circular economies. Regional nature of the facility is altering colored visions of urban biosolid land-application in rural areas.

Melo, T. M. et al. (2019). Management of Biosolids-Derived Hydrochar (Sewchar): Effect on Plant Germination, and Farmers' Acceptance. Journal of Environmental Management (237) 200-214.

This study evaluated hydrothermally converted biosolids (Sewchar) and its effect as a soil amendment on rice, beans, and radish. Hydrochars have lower PAH contents than biochars, contain trace elements below the threshold values for use in agriculture, and yield more alkaline material with higher immobilization potential of trace elements. Study demonstrates higher presence of oxygen-containing functional groups on surfaces of Sewchar than that of biosolids. These results demonstrate higher Sewchar surface activity, with higher potential of water and nutrient retention and cation exchange capacity than biosolids. Biomass responses to Sewchar application into the soil varied with Sewchar dose and type of plant. Survey revealed that younger farmers who had higher education qualifications were more prone to use Sewchar as soil amendment. Farmers who would not use Sewchar as soil amendment attributed the highest level of importance to economic criteria, such as fertilizer and freight prices. Hydrothermal carbonization of sewage sludge presents the potential alternative of using Sewchar as a soil amendment, which is a sustainable option for minimizing and treating waste and reducing the costly transport of wet biomass. detailed research on the migration mechanism of PAHs is crucial for drawing up a legal framework regarding PAH threshold values before Sewchar can be used in agrosystems. Standardization of the HTC process for the production of hydrochar (e.g., Sewchar) is required. An international database would allow the creation of a control mechanism to accurately predict the longevity and durability of Sewchar on the yield of individual crops and soil types.

Oakley, M. (2016). Interim Report for the Water Farming Demonstration Project. Options Assessment and Opportunities Identification: For Nutrient Load Reduction and Surface Water Storage in the St. Lucie River Watershed. University of Florida Center for Landscape Conservation Planning.

Water farming pilot project sites in the St. Lucie River and Estuary Watershed on previously productive citrus groves on private or publicly owned land. Projects for water quality impacts and to help citrus producers hold on to their land while a better cure for greening can be found. Reconnection too costly and timely. Water farming as an interim, or supplemental, or alternative measure to help meet goals. Fast solution but requires payments to private landowners. Need to consider public ownership of the land and water farming infrastructure. Public projects that might be required in the future add to public costs. Need more effective BMPs including personal detention of water. Might require joint private-governmental incentive program to share costs, in situ treatment technologies, and strategic placement of FEB-STAs in priority basins.

Patel, S. et al. (2020). A Critical Literature Review on Biosolids to Biochar: An Alternative to Biosolids Management Option. Rev Environ Sci Biotechnol (19) 807-841.

This paper reviews the literature on biosolids management techniques and their current challenges, biosolids characteristics and its suitability for pyrolysis, pyrolysis product characterization from different reactor designs and biochar application as a soil amendment, adsorbent and catalyst. Studies on the process modeling activities and techno-economic assessments are also summarized. Pyrolysis can reduce the volume of biosolids (up to 70%) and produce energy or value-added products with minimal environmental impacts and contaminants. Overall, biosolids to biochar via pyrolysis can be an effective option for biosolids management, soil amendment, adsorbent, and catalysts. However, the commercial viability of the existing pyrolysis process is limited due to the requirement of biosolids drying prior to pyrolysis; transport of biosolids and requirement of mobile pyrolysis processes; secondary emissions/risks from biosolids pyrolysis; PFAS, microplastics, and pharmaceuticals destruction in biosolids pyrolysis; nutrient recovery from biosolids pyrolysis; effect of biosolids derived biochar on soil biota; lack of policy framework and guidelines for biosolids derived biochar; benchmarking of biosolids derived biochar with biomass-derived biochar; increased concentration of heavy metals in biosolids derived biochar; and lack of pilot-scale demonstrations and life cycle assessments. The results concluded that primary sludge pyrolyzed at 500 degrees Celsius produced the greatest economic benefit and biosolids management cost and biochar sale price were the most critical factors in establishing commercial viability.

Paz-Ferreiro, J. et al. (2018). Biochar from Biosolids Pyrolysis: A Review. International Journal of Environmental Research and Public Health (15) 956.

This article reviews options for the management of biosolids with a focus on pyrolysis and the application of biochar into soil. Land application and composting seemed to be the predominant choice for management in EU-15 after the sewage sludge directive, followed by incineration. Incineration reduces biosolids volume up to 70% and removes pathogens and toxic organic compounds. However, incineration is a costly alternative due to the external requirements of energy associated with dewatering and regulations in air pollution. Co-incineration is becoming increasingly popular compared to mono-incineration but incineration is perceived poorly by the community altogether. Landfilling is common due to reduced costs but is becoming increasingly restricted in different countries, the cost of land is increasing, and there are methane emissions. Compared to other alternatives, pyrolysis has a lower carbon footprint. Adsorbents obtained from biosolids pyrolysis can also be more effective than activated carbon in eliminating H2S and NOx generated in thermochemical processes. Releasing/treating pollutants through pyrolysis allows char to be landfilled, combined with composting, or used as a growing media. Increasing number of studies concerning the use of biochar as soil amendment due to its numerous advantages including the improvement of soil productivity, remediation of contaminated soils, and climate change mitigation. Pyrolysis reduces the volume of biosolids and eliminates pathogens while biochar has high amounts of carbon and nutrients. While biochar contributes to an increase in soil pH and cation exchange capacity, some biochars can bind nutrients in soils and limit their accessibility for plants. Biochar contributes to retaining soil nitrogen in the long-term, acting as a slow-release fertilizer.

Rebgetz, L. (2022). Human Waste Turned into Renewable Energy at Australia's First Biosolids Gasification Plant. ABCNews. Web. Human waste turned into renewable energy at Australia's first biosolids gasification plant - ABC News

Australia opens its first biosolids gasification plant. Sewage is dried and burned to produce gases that power the facility. Biochar is then produced to use as fertilizer as chemicals, including microplastics, are destroyed. Reduces carbon emissions by ~6,000 tons a year and saves the council $1 million annually, especially with transportation. Overall, it took 18 months to build the $28 million facility with $6 million from the Australian Renewable Energy Agency.

Scullion, M. (2013). Biosolids Dewatering Alternatives for Orange County Florida Water Resources. Journal. Web. Biosolids Dewatering Alternatives For Orange County Florida Water Resources Journal : June 2012 - Biosolids Management & Bio-Energy Production (bluetoad.com)

Rotary fan press produced cake solids marginally better than the belt filter presses. Screw press produced solids content above 17 percent when optimized, 20 percent from the centrifuge. Use of a centrifuge or screw press as an alternative dewatering technology can be expected to significantly outperform the existing belt filter presses (26 to 32 percent/76 to 93 wet tons per day reduction in biosolids cake). Dewatering results in significant reduction in operation and maintenance costs associated with contract hauling and land application of biosolids. Can offset capital costs associated with replacement of existing equipment. Electro-dewatering results in over 100 percent of increase in solids content. Increasing polymer dosing rate increases solids content to a certain limit. Screw press has seven to ten times less energy consumption than that of a centrifuge.

Semblante, G. et al. (2015). Trace Organic Contaminants in Biosolids: Impact of Conventional Wastewater and Sludge Processing Technologies and Emerging Alternatives. Faculty of Emerging and Information Sciences – Papers: Part A. 4220

Aerobic or anaerobic digestion being used in wastewater treatment and conversion to biosolids. Concern over trace organic contaminants (TrOCs). Studies show TrOC biodegradation preferentially occurs under aerobic conditions(air flotation, aerobic digestion, and composting). Anaerobic digestion has lower operating costs and potential to generate energy. TrOCs can be minimized with advanced treatment processes including ozonation, UV oxidation, and bioaugmentation. PH, sludge retention time (SRT), temperature, and the addition of sorbent materials influence TrOC sorption and biodegradation. Thickening under aerobic conditions may contribute to TrOC biodegradation in the sludge treatment line, but may require additional energy for aeration and water pumping. The low environmental impact of hydrogen peroxide and wide availability of ferrous ion sources provide Fenton treatment an economic advantage over other oxidation processes (e.g. ozone and photocatalytic treatment) that have high energy consumption and potential environmental risks. Thermal treatment has been found to have varying impact on TrOC removal from sludge. Only a few studies have investigated TrOC removal from sludge by bioaugmentation. Ozonation and ultrasonication appear to demonstrate the greatest potential to eliminate TrOCs from biosolids. Bioaugmentation using exogenous organisms, being a biological process, is potentially more environmentally friendly and cost effective than advanced oxidation processes.

Treadway, T. (2018). Biosolids Ban on Treasure Coast Regional Planning Council Agenda. TCPalm. Web. https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2018/07/17/treasure-coast-planning-council-stop-using-biosolids-fertilizer/788872002/

Council calling for statewide ban on biosolid application and alternatives for disposal. Action to get people to start talking about the issue (Florida Association of Counties, League of Cities, Small County Coalition). Municipalities incentive by money for disposal. 6-month moratorium in Indian River County. Florida's sewage treatment plants produce about 340,000 dry tons of sludge a year (100,000 = Class B 140,000 = Class AA). The 240,000 tons combined contain 33 million pounds of nitrogen and 13.2 million pounds of phosphorus. Omni Processor technology turns the nitrogen and phosphorus in biosolids into usable fertilizers, produces enough energy to power the conversion facility, and makes distilled water. "In a demonstration at a test facility in the west Africa country of Senegal, Gates drank a glass of water that five minutes before had been raw sewage."

Treadway, T. (2018). Biosolids Ban Encouraged by Treasure Coast Regional Planning Council. TCPalm. Web. https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2018/07/20/treasure-coast-regional-planning-council-encourages-biosolids-ban/797400002/

Treasure Coast Regional Planning Council looking for alternatives to biosolids (phasing out land application and pilot programs for alternative means of disposal). Alternatives involve increasing utility rates. Technological alternatives to convert biosolids to fertilizer, energy, and distilled water. Biosolids are less likely to run off into waterways than commercial fertilizer. Test in the middle of algae bloom or nearby?

Wang. R. et al. (2019). Energy Recovery from High-Ash Municipal Sewage Sludge by Hydrothermal Carbonization: Fuel Characteristics of Biosolid Products. Energy (186) 115848.

The energy efficiency of classical thermal treatment methods, such as incineration and gasification, is limited because sludge has to be subjected to high-expenditure preliminary drying. Additionally, when sludge is thermally dried, a series of problems including emission of fine dust particles, leakage of foul odor, and post-treatment of condensate wastewater must be settled urgently. High-temperature hydrothermal carbonization (HTC) over 290 degrees Celsius could remove some alkali or alkaline earth minerals completely. HTC temperature at 230 degrees Celsius is optimal for the fuel upgrading of HA-MSS. The dewaterability, which affected the economic cost for the sludge treatment, was significantly improved. The filtrate from 230 degree Celsius HTC contained high levels of COD and TOC, which could be converted into biogas through the AD method.

Williams, T. (2018). Nutrient Recovery and Sustainable Biosolids Management. Web. PowerPoint.

Waste activated sludge from a BNR facility contains approximately 12% N and 5% P. Can be recovered as struvite. Benefits of nutrient recovery include lower energy use and GHG emissions, lowers biosolids P content for higher land application rates, recovers N and P as struvite for a slow-release fertilizer, and more. 80-90% of P and 10-40% of N removal. Savings in maintenance costs (pipe clogging and abrasion of centrifuges) and sludge dewatering and disposal. Struvite can be sold as well. Tools for Evaluating Resource Recovery (TERRY) can be used to evaluate feasibility of implementing extractive nutrient recovery and criteria such as cost, technology performance, environmental and social impacts, plant-wide impacts, etc.

Wilson, W., Betancourt, F., & Hagan, D. (2013). How Sidestream Phosphate Removal Can Benefit Biosolids Management Programs in Florida. Florida Water Resources Journal. Web. How Sidestream Phosphate Removal Can Benefit Biosolids Management Programs In Florida Florida Water Resources Journal: June 2013 - Biosolids Management and Bioenergy Production (bluetoad.com)

Article highlights the benefits of nutrient recovery by controlled struvite precipitation including reduced precipitation of nuisance struvite, decreased chemical requirements for phosphorus removal, and payback from sale of struvite pellets considering the global limitation on raw phosphorus and chemical processes/maintenance issues involved with anaerobic digestion. In Florida, struvite recovery reduces nutrients in sensitive watersheds. In-plant recovery reduces effluent phosphorus discharge while also reducing phosphorus discharge via biosolids. Also eliminates metal salt addition for phosphorus removal and increases the amount of available biosolids while reducing hauling costs and crop biomass required to meet zero net import requirement. Translates to less required land application field area. Altogether, cost benefit of $51,000-$73,000 per year. Cost analysis dependent on regulatory, geographic, and public environment. Considering in-plant impacts of struvite recovery (omitting hauling related costs), net annual benefit of $66,000. Considering in-plant and hauling, project is highly favorable in terms of costs, with a payback period of less than five years.

Wirtel, S. (2018). Pyrolysis Provides a Cost Effective, Non-Land Based Solution to Organic Waste Management. Web. PowerPoint.

Pyrolysis converts biogenic feed to gasses and carbon through a self-sufficient energy process. Los Angeles project is capable of 30 tons per day. Kore process recovers embedded energy to reduce volume by over 90%. Can also produce renewable hydrogen and biochar (9,000 sq. ft./gram). Biochar results in improved nutrient retention, improved moisture retention, enhance microbial activity, increased cation exchange capacity, permanent carbon sequestration, and reduces citrus greening (improves crop productivity and health, 67% more canopy volume). H2 fuel cells generate power with zero emissions.

Xia, L. et al. (2019). Incorporation of Biosolids as Water Replacement in a Two-Step Renewable Hydrocarbon Process: Hydrolysis of Brown Grease with Biosolids. Waste and Biomass Valorization (11) 6769-6780.

Research highlights the incorporation of biosolids into the hydrolysis step of a two-step thermal conversion of lipids (Brown Grease) for production of renewable hydrocarbons, which can be utilized as renewable fuels. Results indicated no significant difference in the degree of hydrolysis of brown grease when biosolids was used as water replacement. The fatty acids composition after hydrolysis when biosolids was used as a water replacement also remained largely unchanged. The rapid settling of solid material in biosolids after thermal hydrolysis of brown grease may reduce the necessity of biosolids settling lagoons. The key issues surrounding the disposal of biosolids are their extremely high water content (93–99% water) and their incredibly slow rates of settling, which make the removal of solid materials inefficient and/or costly. In this manner, it may be possible to reduce costs associated with water usage during production of renewable fuels and chemicals, while at the same time provide a strategy for disposal of biosolids.

Biosolids Operations

n.a. (2019). Blue Cypress Lake. Presentation to the Florida Stormwater Association Annual Meeting.

2017 application of Class B Biosolids was substantial in Blue Cypress Lake Watershed, but well below permitted levels. High possibility of increasing phosphorus loadings in Blue Cypress Lake. Pressley Ranch presents drastically higher levels of TN and TP compared to Blue Cypress WWTF. 89% of biosolids applied in the upper St. Johns River Basin originate from sources outside of the district. Applications began in 2006 and increased significantly in 2013 when banned in Lake O' and Caloosahatchee watershed. Allowable amounts of biosolid applications exceed soil storage capacity according to UF/IFAS research.

Amerson, S. (2018). Martin County Utilities and Solid Waste. Web. PowerPoint.

Martin County collects and processes approximately 4.5 million gallons of raw sewage each day at Tropical Farms and North Jensen WWTP to use as reclaimed water for irrigating residential, golf courses, and other public areas. Neutralizer and chemical processes being used at Class AA-EQ. Dewatering results in a minimum of 18% solids or higher

Baker, M. Florida Department of Environmental Protection. (2018). Biosolids Use and Regulations in Florida. Web. PowerPoint.

This presentation describes biosolids and biosolids use and regulations in Florida. Total production is about 340,000 dry tons per year. 10,000 – 20,000 dry tons of pellets are imported and distributed and marketed as "fertilizer." Use or disposal options are based on permits issued and include the transfer to another facility, landfill, distribution and marketing as "fertilizer" (Class AA/fertilizer license required), incineration, bioenergy, and land application (Class B). Land application sites are required to develop a site-specific NMP and site restrictions based on cumulative pollutant loading limits (Fertilizer license required. Additional requirements in Northern Everglades and Estuary Protection Program areas. Class AA biosolids distributed and marketed as "fertilizers" are exempt.). Custom blends not reported). 39 Florida facilities produced 191,344 dry tons of final Class AA biosolids product (187,149 dist./marketed in Florida, 4,195 outside, 9,966 imported). Approximately 140 permitted land application sites in Florida. Haulers are the most common site permittees. Alternative technologies include gasification (Sanford – no longer operating), Supercritical Water Oxidation (Orlando pilot project), Anaerobic Digestion/Methane production (significant volume of biosolids leftover, Orlando/St. Pete facilities), WTE facilities (few facilities have option in permit, usually dried or pelletized, air permit required/mercury concerns)

Bottcher, D. (2018). Watershed Assessment Model (WAM) for Evaluating Existing Sources and Future Abatement Scenarios. Web. PowerPoint.

The WAM simulates surface and groundwater flow and TSS and nutrient loadings specifically for Florida conditions. Legacy P in the Okeechobee Watersheds amounts to 190,000 mt. 380 years to wash out existing legacy P at current P discharge levels.

Charest, E. (2018). Indian River County Utilities Department. Web. PowerPoint.

The county provides sewer collection services for over 28,600 customers. Historically received hauled wastes from numerous counties; Okeechobee, Palm Beach, Brevard, St. Lucie, and Martin. Later restricted treatment to wastewater originating within the county allowing for adequate wastewater treatment. Dewatered biosolids disposed at IRC landfill and same site as facility

(SYNAGRO). The entire process is reduced and trucking costs decrease for a cost-effective approach.

Florida Department of Environmental Protection. (2022). General Facts and Statistics about Wastewater in Florida. Web. https://floridadep.gov/water/domestic-wastewater/content/general-facts-and-statistics-about- wastewater-florida

Florida Department of Environmental Protection. (2018). Florida Biosolids by Quantities 2014 – 2015 – 2016. Florida Summary Request.

197,115 lbs of Class AA biosolids distributed and marketed within Florida. 101,032 lbs of biosolids land applied by Florida facilities within Florida. Estimated 88,400 lbs of biosolids landfilled. Broward, Palm Beach, Sumter, and Lee Counties producing class AA quantities over 10,000 (Bioset-Alkaline, Pellets, and Compost). Broward, Hillsborough, Miami-Dade, and Seminole Counties land applied Class B over 10,000 lbs. Class B land application sites over 10,000 lbs include Gadsden to Kingry Farm and Osceola to Deseret Ranches. No land application site data for Broward, Hillsborough, Miami-Dade, and Seminole.

Florida Department of Environmental Protection. (2014). Biosolids in Florida: 2013 Summary. Domestic Wastewater Program.

Florida domestic wastewater facilities generate an estimated 320,000 dry tons of biosolids annually. Class AA biosolids may be distributed in bulk or may be bagged for retail sales. About 178,511 dry tons of Class AA biosolids distributed and marketed in Florida during 2013 (157,853 produced by Florida). Projected increase. Florida N – Viro/Tomoka RMF biggest producer at 29,776.51 dry tons. Biosolids land-applied in Florida appear to be exclusively Class B. About 97,880 dry tons of biosolids land applied in 2013. 46,249 acres of land applied with biosolids in 2013 (average TN and TP content 5.27% and 2.30% respectively). About 111,923 dry tons of biosolids disposed in landfills in 2013. Contributing factors include increased number of restrictive county ordinances, rising energy costs, restrictive legislation for sensitive watersheds, and revisions to Ch. 62-640 F.A.C. Almost all sites in Florida grow hay crops or are pastures. No biosolid incinerator but several waste-to-energy facilities. No significant changes projected/identified.

Hadjimiry, H. (N.d.). Palm Beach County Utility Dept. Web. PowerPoint.

This PowerPoint describes the wastewater treatment process in Palm Beach County. 18 wastewater treatment facilities are located in the county; serving 1.5 million people (third largest populated county in Florida), treating 110 mgd, and producing 137,000 T/yr. The Solid Waste Authority (SWA) receives sludge from the City of Boca Raton, SCRWWTF, Jupiter LRECD, PBC SRWRF, and Seacoast. The ECRWRF receives sludge from Ocean Maisonette WWTP, Wellington Arms Condo, Colonial Crown Manor, The Dunes of Ocean Ridge, Ocean Harbor Estate, Sunshine Meadows, Pelican Cover, Ocean Ridge Yacht Club, and Ocean House North to send to SWA. The SWA sends this sludge to NEFCO to produce Class AA. The Village of Wellington produces Class AA. PBC WR Belle Glade and PBC WRN Pahokee send sludge to McGill Brinton Organic Compost & OMNI Waste of Osceola County. Monthly averages and maximum levels of As, Cd, Cu, Pb, Hg, Mo, Ni, Se, Zn reported.

O'Connor, G. A., et al. (2004). Phytoavailability of Biosolids Phosphorus. Journal of Environmental Quality (33) 703-712.

Study on common pasture grass grown in two P-deficient soils amended with 12 biosolids (Two produced via biological phosphorus removal, one pelletized BPR, and one BPR supplemented with Al) and a commercial fertilizer reports differences in the phytoavailability of P in various biosolids. Applying biosolids based on crop N needs supplies excess P to an ecosystem because the N to P ratio of biosolids is narrower than N to P ratio needs of crops. Low, dictated rates can severely reduce a farmer's interest in utilizing biosolids and a municipality's ability to economically dispose of a growing residual product. Biosolids P phytoavailability might be expected to depend on the residuals treatment process used because they affect the forms and solubilities of P in biosolids (Biosolids treated with Ca salts had greater P phytoavailability and thermal drying significantly reduced release of biosolids P compared with dewatered digested cake). Research concludes that only two biosolids produced via BPR exhibited P phytoavailability in the high category (No supplemental salts added for P precipitation). Within the moderate group are biosolids produced by conventional wastewater and solids digestion and additional treatments like composting (48% relative bioavailability). Lower P availability characterizes biosolids containing very high total Fe and Al concentrations/dry materials. P phytoavailability is a complex function of many properties of the soil, climate, and vegetation, as well as the nature of the P source.

Perkins, T. (2022). "I Don't Know How We'll Survive": The Farmers Facing Ruin in America's "Forever Chemicals" Crisis. The Guardian. Web. 'I don't know how we'll survive': the farmers facing ruin in America's 'forever chemicals' crisis | Maine | The Guardian

High PFAS levels found in farms across the state of Maine after application of biosolids as fertilizer. The state has now approved a near ban of PFAS and is developing a proposal to prohibit biosolids that haven't been tested for PFAS. Farmers are struggling financially and worried about health impacts from contaminated food. High levels of PFAS have also migrated miles from application sites. Only one out of a thousand PFAS monitored in beef and milk with high limits. Two PFAS regulated in sludge but sludge exceeds the limits. New restrictions limit combined sludge and clean soil PFAS levels as well as allowing sludge to be composted and spread. Although, not enough landfill space (9% to 12% increase in space after legislation), and customers' water and sewer bills will increase. Federal money to control utility costs and the elimination of a new utility fee would help. Big composting operation involved.

Roderick, G. (n.d.) Review of FDEP Proposed Rule Changes to FAC 62-640.

Class AA biosolids are twice the volume of Class B and are exempt from regulation because they meet the definition of "fertilizer" and "right to Farm Act" provisions. Bahia pasture grass does not need supplemental TP yet that is where the majority of Class B biosolids are going. Applications based on either TN or TP and PAN. Issues with more TP when based on TN and issues with legacy nitrogen in the soil when applying 2.5 times the amount. "Pastures not fertilized with P since 1986 still had 5-7 times the amount of P in drainage ditches compared to unfertilized pastures." Exceeding imports vs exports by 3 v 1 for TN and 2 vs 1 for TP. Influence of voluntary agricultural BMP program is limited. Alternative technologies are required. Moving around the problem will not solve anything. Restricting applications to Class AA does not help either.

Salman, J., Borresen, J., Chen, D., & Le, D. (n.d.) Aging Infrastructure and Storms Contribute to Massive Spills. USA Today. Web. https://stories.usatodaynetwork.com/sewers/

100s of 1000s of gallons of sewage flowing into surface waters as a result of failing and aging infrastructure. 1.6 billion gallons of wastewater released by deteriorating systems in Florida over the past decade. 23,000 failures over the past 10 years. Utility officials resorting to patchwork repairs due to high costs. Wastewater causing algae blooms. Heavy rainfall associated with back ups and overflows. DEP ensuring outreach prior to heavy storms. Millions of dollars invested in restoration but billions required. Costs add up the more municipalities wait.

Shaddox, T., & Unruh, J. (2017). Florida Fertilizer Usage Statistics. University of Florida Department of Environmental Horticulture, UF/IFAS Extension.

Florida crops require nutrient applications due to presence of year-round crops and low nutrient retention (citrus, cattle, vegetables, etc.). Non-farm sector includes nurseries, golf courses, home lawns, and gardens. Farm use responsible for more than 82% of N, P, and K consumption. Clear evidence identifying N and P contributions to water bodies by market sector does not exist. Slow-release fertilizers less likely to impact on non-point source pollution than soluble nutrient sources.

Silveira, M. L. et al. (2019). Runoff and Leachate Phosphorus and Nitrogen Losses from Grass-Vegetated Soil Boxes Amended with Biosolids and Fertilizer. Journal of Environmental Quality (48) 1498-1506.

The upper basin of the St. Johns River currently receives about two-thirds of Florida's Class B biosolids land application. This study characterizes the main biosolids sources routinely applied in the region and evaluates runoff and leachate N and P losses from a typical Florida Spodosol amended with biosolids or commercial inorganic fertilizer. Active permitted biosolids application sites account for ~12% of the SJR basin. P concentrations have increased significantly, mainly near bahiagrass pastures and citrus farms. Majority of biosolids applied within the SJR are produce by 33-39 treatment facilities around Florida (36% Miami-Dade, 12% Orlando, 11% Broward, 9% Tampa, <1% Bradenton and St. Pete). Soluble reactive P (SRP) was the predominant form of P lost in runoff and leachate. Inorganic P fertilizer increased flow-weighted runoff total P concentrations nearly 60-fold relative to control treatment. With the exception of biological P removal (BPR) biosolids, all other tested biosolids yielded flow-weighted runoff P concentrations similar to untreated soils. Cumulative P and N losses were greater from commercial inorganic fertilizer than any biosolids source. Efforts to minimize offsite P losses in the SJR basin should account for the solubility of applied P sources. Data also support the usefulness of WEP as an indicator of biosolids P loss potential.

Silveira, M. (2018). UF Range Cattle Research. Web. PowerPoint.

Soil testing is not a reliable tool for bahiagrass fertilizer management decisions, and is not recommended. Fertilizer decision for bahiagrass pastures should be based on the economics of your operation. Tissue plus soil testing provides a better diagnostic tool to predict bahiagrass P requirements. Mean % of water-extractable P highest for TSP (85%) and dairy (50%), poultry (20%), and aerobic and anaerobic conventional biosolids (~2%). Water-extractable P by biosolids type highest in BPR Cake Biosolids (14%) and Alkaline Stabilized Biosolids (~8%), Composted Biosolids (~3%), Conventional Biosolids (2%), and Heat Dried Biosolids (<1%). Agronomic optimum (26 ppm M3-P). Change point at ~3-4 times the Agronomic optimum. Class AA results in highest Bahiagrass Herbage Accumulation (lb/A) cumulatively, followed by Class B (St. Pete), Commercial fertilizer,

Class B (Bradenton), and control. Inorganic fertilizers show higher leachate peaks compared to Class B. Class B remains constantly low.

Silveira, M. (2008). IFAS Changes Protocol for Generating P recommendations for Established Bahiagrass Pastures. The Florida Cattleman and Livestock Journal.

Bahiagrass may produce satisfactorily without phosphorus fertilization through access to deep soil depths. Depends on amount of grazing and/or haying production along with fertilization. Optimum soil pH for Bahiagrass is 5.5. Best practice to combine soil samples with forage samples.

Smith, N. (2016). More Indian River Lagoon Evidence: The Enemy Is Us. Sunshine State News. Web. http://www.sunshinestatenews.com/story/more-indian-river-lagoon-evidence-enemy-us

Millions of gallons of waste are pumped directly into the Indian River Lagoon from municipal sewage plants. Cities are allowed 90 days of emergency discharges during heavy rains. "The plant discharged 25 days last year, averaging 4.6 million gallons per day." "This year, the plant has discharged for five days, averaging 4.8 million gallons per day." Planning on deep injection well. Information references Waymer, 2016.

Soil and Water Engineering Technology, Inc. (2007). Technical Assistance in Review and Analysis of Existing Data for Evaluation of Legacy Phosphorus in the Lake Okeechobee Watershed: Task 2 – Evaluation of Existing Information.

Majority of P accumulation occurring within last 50 years. Shift from vegetable crops to increasing cattle crops, dairy farms, and residential and urban development associated with rapid population growth (landscape fertilization, septic tanks, WWTPs, and landfills). The effects of these processes on the accumulation of legacy P and its associated impact on water quality are determined by land use patterns and management and phosphorus discharge associated with each land use. This study found that in the 11 years since the previous study, total net P import into northern Lake Okeechobee region had fallen annually 16% to 2,001 mt per year. The reductions were attributed to BMPs and the governmental buyout of some local dairies (1997 to 2001). Truck crops represent less than 2 percent of the anthropogenic land uses in the region, but contribute 42.5% of the net P import. Phosphorus discharges from this region (Upper Chain of Lakes) have been relatively low suggesting that P is being retained onsite and also within the lakes in the region. Some of this P, however, could be Task 2 – Legacy P 19 released in the future through leaching or mixing caused by heavy storms. The western Lake Okeechobee drainage basin is the only remaining region that has not been analyzed. However, this basin contributes a relatively small amount of discharge and associated phosphorus load to the lake. Runoff is the most dominant flow path for washing legacy P from the upland soils and delivering water to down gradient wetlands and streams and ultimately Lake Okeechobee. BMPs include trees within Bahia grass pastures, retention/detention (40 to 60% TP reductions), SAV, hybrid wetland systems, etc.

South Florida Water Management District. Nutrient Budget Analysis for the Lake Okeechobee Watershed. PowerPoint.

TP imports vs exports ~ 2:1. TN imports vs exports ~2.7:1. Class AA P amounts to 877 metric tons. Class B P amounts to 436 metric tons. Total P = 1,313 metric tons and Total N = 3,284 metric tons. Class AA Biosolids mostly applied in South/Central Florida. DEP will allow nitrogen-based loading for zones with a "Low" or "Medium" potential for P transport. NMPs can easily manipulate TP transport to be medium or low simply based on overland "setbacks." Agriculture's share of total

required TP and TN reductions remaining as of 2015 are 85.01% and 94.55%, respectively. Every crop in Florida can be grown profitably without the use of biosolids as a source of fertilizer.

Treadway, T. (2018). Is Blue Cypress Lake Phosphorus Pollution from Pressley Ranch's Biosolids? TCPalm. Web. https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2018/06/01/biosolids-blue-cypress-lake-stick-marsh/541420002/

Blue Cypress Lake polluted from Pressley Ranch biosolid applications. Direct link from lake phosphorus to biosolids hasn't been proven. Biosolid-dumping increased since bans in Lake Okeechobee and St. Lucie watersheds. Blue Cypress is one of the most polluted lakes in this region. Biosolids applied to grow Bahia grass for cattle grazing. Most of the biosolids shipped from south Florida (~85% water). Over-dumping issues. $1.08 million to transport. Permit for Class B biosolids approved on Pressley Ranch (cannot apply within 1,000 feet of the lake or during inclement weather). Compliance based on conflicting schedules (not showing true application results). Indian River County treats and disposes locally to landfill. Other Treasure Coast cities ship to area farms or Okeechobee landfill.

Waymer, J. (2016). Is Sludge Also Sickening the Lagoon? Florida Today. Web. http://www.floridatoday.com/story/news/local/environment/2016/05/20/sludge-also-sickening-lagoon/83874988/

Uncertainties related to amount of sludge being deposited into the lagoon. "Yearly, about 300,000 dry tons of biosolids contribute 33 million pounds of nitrogen and more than 13 million pounds of phosphorus into the state's watersheds." Septic to sewer conversion are not enough. "Class AA and B biosolids contain an average 5.5 percent nitrogen and 2.2 percent phosphorus." "Of the 300,000 dry tons of sludge produced annually in Florida, 37 percent gets spread on land, 34 percent goes to landfills and 29 percent is distributed and marketed as commercial fertilizers." "Seven sites totaling 17,476 acres in Osceola County took 51,719 dry tons of class B sludge in 2013." "The Osprey plant on Buffalo Road applied 213 dry tons of class B sludge in 2013. That sludge goes on 200 acres about a mile west of Interstate 95, northwest of Aurantia Road." "Volusia has among the highest volume of marketed and distributed class AA sludge "fertilizer" along the lagoon, producing 29,777 dry tons in 2013" "Audubon of Florida in 2009 estimated sludge was getting spread on the watershed at 450 to 1,620 times the ideal level to meet nitrogen and phosphorus limits for Lake Okeechobee." Direct disposal of sludge, "The plant discharged 25 days last year, averaging 4.6 million gallons per day." Solutions: "Martin County banned spreading A and B sludge, but not class AA," export to nutrient-poor areas, convert to energy/regional plant.

Williams, A.B., & Daprile, L. (2017). Treated waste fertilizes crops, but can fuel algae blooms. News-Press. Web. http://www.news-press.com/story/news/2017/05/20/investigation-human-waste-fertilizes-farms-fuels-lagoon-algae-blooms/97895956/

"Florida domestic waste treatment plants annually produce some 320,000 tons of biosolids, also called sludge, the state's department of Environmental Protection estimates." "Of that, only a third of it ends up in landfills or biofuel plants." "Class B biosolids are minimally treated and banned in certain watersheds, including the Caloosahatchee's and Lake Okeechobee's." "There is only one permitted Class B dump site in Lee County and that's Corkscrew Ranch in Estero. Collier has two: one at the Ranch One Grove in Immokalee and the other at BCI south of Ave Maria." "But Boyd thinks it's likely only the Immokalee site is active, because the other two weren't used at all in 2015,

the last year for which records were available." "The only way to figure out where Class AA biosolids go is to do what the state doesn't: compile and check map treatment plants' shipping records" (doesn't tell you where it is being applied). "Collier County spends some $1.7 million annually to haul its biosolids to a landfill near Okeechobee." Lack of regulation. "The 317-acre farm was covered in a layer 2 feet deep with mountains piled 12 feet high and wet pools turning blue and green — but no commercial sod in sight." Stats on sewage treatment facilities and processed biosolids.

United States Environmental Protection Agency. (2009). Targeted National Sewage Sludge Survey Statistical Analysis Report.

Report on estimates of pollutant concentrations in biosolids that represent POTWs in the U.S. with flow rates of at least 1 million gpd, in operation in 2002 and/or 2004, and employed minimum of secondary treatment. EPA identified eight target analytes, along with molybdenum, 4 PBDEs, 14 pharmaceuticals, and 7 steroids and hormones. Eight target analytes had detection percentages of at least 74%, with four achieving 100%. PBDEs, Pharmaceuticals, steroids, and hormones had estimated detection percentages of at least 90%.

Walker, C., Mason, S., & Bednar, D. (2018). Sustainable Development and Environmental Injustice in Rural Ontario, Canada: Cases of Wind Energy and Biosolids Processing. Journal of Rural and Community Development (13) 110-129.

This multiple case-study approach with in-depth qualitative interviews examines the politics of two techno-industrial developments within a complex urban-rural perspective of development based on sustainability goals. Prior to the study, there was a government-initiated drive towards increasing renewable energy and circular economies via wind energy development and biosolid processing. It is noted that development has emerged from an urban-based policy system and environmental injustices are occurring in rural communities. Additionally, the volumes of urban-based sewage has increased as governing agencies promote land application. Findings indicate perceptions of disconnect from the urban as well as increasing political heterogeneity and conflict in rural communities. Furthermore, rural residents don't feel empowered and burdened by urban problems/waste created by urban policies and policymakers. Rural residents also indicated the absence of local economic benefit. More specifically, the non-agricultural rural population deals with the sights, sounds, and smells without benefits of land-application. Participants suggest that waste should be treated where it is created. Authors recommend local control and/or consultation during the planning and siting stages of development. Rural residents value natural, recreational, and restorative aspects of rural communities rather than primary production or extractive industries.

Walsh, P. (2018). St. Lucie County Utilities Department. Web. PowerPoint.

St. Lucie County Utilities serves 12,500 customers with 5 wastewater treatment plants, 2 water plants, 172 miles of pipe, and 60 lift stations. Single Stream Processing Facility has cost savings in overtime of 90% and 50% increase in recovered materials. Expansion of Class I landfill to result in long-term disposal in efficient and cost-effective manner. Working with Martin County to process single stream material sources. Recycling Mutual Aid Agreements formed.

Youngquist, C. P. Goldberger, J. R., Doyle, J. & Jones, S. S. (2015). Public Involvement in Waste Management Research and Decision-Making: A Case Study. Regional Science Policy & Practice (7) 141-162.

This paper examines the role of the US land-grant co-operative extension system in achieving effective community engagement around waste management through a collaborative effort between researchers at Washington State University the town of La Conner, Washington. Four concepts of resilient decision-making are used as a framework for evaluation (Risk communication and management, public knowledge systems, the public-expert interface, and visibility of wase and awareness of waste issues within communities). Public concern about biosolids recycling primarily revolves around the issue of contaminants. The problems caused by this approach, wherein public opposition is regarded as a nuisance or obstacle, are compounded by failure of formal public participation methods commonly required by law (i.e., review-and-comment periods and public hearings) to achieve genuine and meaningful participation in public planning processes. Extension is a national research and educational network charged with providing "useful, practical and research-based information to agricultural producers, small business owners, youth, consumers and others in rural areas and communities of all sizes" (http://www.csrees.usda.gov/Extension/). The La Conner WWTP produces Class A biosolids compost available free of charge to residents and sold in bulk to local landscaping and topsoil companies. The WWTP is only 200 feet from Sullivan Slough, which drains directly into Skagit Bay, and adjacent to an organic farm with a retail stand 500 feet from the nearest biosolids compost bay. In 2009, the mayor requested that the WWTP increase acceptance of outside septage as a way to increase revenue (increase in odor events/complaints). Results show that the general public frames risk more broadly than technical or scientific experts. The town council and WWTP managers did not host any public forums or town hall style meetings beyond regularly scheduled town council meetings because of resistance from individual council members. More community involvement in the early phases of decision-making may have led to greater resiliency in the decision-making and public-communication process, which in turn may have reduced the amount of time and resources spent on mitigating odor concerns, addressing accusations of mismanagement and preparing for and attending emotionally intense community meetings. Public scientists and research institutions have an important role to play in the process of including the community in both defining and solving problems. In the case of La Conner, a temporary increase in unpleasant odors and visibly larger piles of compost may have increased the interest and concern about biosolids and led to a stronger desire in some individuals to get involved in the decision-making process.

Zhang, J. et al. (2016). Lake Okeechobee Watershed Tributary Nutrient Loading Trends WY2006-WY2015. South Florida Water Management District.

Tributary analysis of TP and TN. No sites with decreasing trends.

Economics

Hart, D. (2013). Sludge Hauling: Lessons Learned. Florida Water Resources Journal. Web. How Sidestream Phosphate Removal Can Benefit Biosolids Management Programs In Florida. Florida Water Resources Journal: June 2013 - Biosolids Management and Bioenergy Production (bluetoad.com)

Company was losing over $100,000 a year in hauling costs due to 8-10 inches of sludge remaining in trailers after dumping. After many failed attempts, the contract was changed to tons hauled versus the existing loads. Facilities need to require the hauler to be charged for sludge dumped instead of sludge hauled.

Hazen & Sawyer. (2011). Compilation of Benefits and Costs of STA and Reservoir Projects in the South Florida Water Management District. Florida Ranchlands Environmental Services Projects.

Document listing phosphorus reduction per year and costs associated with project and phosphorus reduction for different STAs. Environmental benefits and geographical information listed as well.

Kone, D. (2010). Making Urban Excreta and Wastewater Management Contribute to Cities' Economic Development: A Paradigm Shift. Water Policy (12) 602-610.

Sanitation infrastructure *is disconnected from business opportunities which use resources such as water, nutrients, or biosolids for their productive activities. Failure in sanitation is putting a huge financial burden on municipalities who have to rely on permanent subsidies to operate and maintain infrastructures. Latrine programs for areas lacking sanitation infrastructure do not provide reliable solutions for emptying latrines and for the transportation and treatment of fecal sludge and wastewater. WHO introduced new guidelines for dealing with sanitation in developing countries that links sanitation with agriculture productivity, agriculture business, and examines additional reuse pathways for wastewater. For example, the use and sale of forage plants in macrophyte-based systems can contribute to keeping treatment works operational and cover maintenance costs. Most developing countries have on-site treatment and it is a challenge to find low-cost options. Sludge collection and haulage are conducted by private entrepreneurs. Decision makers are reluctant to legalize wastewater irrigation since the wastewater is still contaminated with pathogens.*

Roderick, G. (2022). Harmful Algal Blooms and the Land Disposal of Biosolids – What are the Real Costs?. ECOMagazine. Web. https://www.ecomagazine.com/in-depth/featured-stories/harmful-algal-blooms-and-the-land-disposal-of-biosolids-what-are-the-real-costs

54% of human TP into surface waters comes from domestic human waste. 38% from agriculture. Hundreds of billions of dollars required to repair Florida's failing infrastructure. $314.6 million annual burden to state of Florida for TN and TP surface water clean-up. All agricultural crops can be grown profitably without the use of biosolids. $2 million for every 100 homes failing septic to central sewer conversion. $6,000 cost per home to connect to sewer. $5 to $10 billion for converting 3% to 6% of the population to central sewer. Converting all biosolids annually produced in Florida to renewable products costs $500 million to $600 million and annual operating cost of$60 million with a return on investment and profit achieved within 8 years. Technology could qualify for funding from the 319 Nonpoint Source Pollution Program.

Roderick, G. (2021). Harmful Algal Blooms and the Land Disposal of Biosolids - What Are the Real Costs? EcoMagazine. Web. https://www.ecomagazine.com/in-depth/featured-stories/harmful-algal-blooms-and-the-land-disposal-of-biosolids-what-are-the-real-costs

The land disposal of biosolids is increasing the nutrient content of surface waters and contributing to chronic HAB events. Agricultural runoff and failing septic/sewer infrastructure are noted as the main sources of pollution. High removal costs and infrastructure repairs are costly, acutely hazardous, but regulations don't provide too much protection and funding is not prioritized. New

technologies are increasing the efficacy and efficiency of nutrient application from biosolids and biosolid activity and recommendations are made for infrastructure repair and legislation.

Roderick, G. (2019). What is Fueling Harmful Algal Blooms in the United States. Ecomagazine. Web. http://digital.ecomagazine.com/publication/?i=620331&ver=html5&p=1#{"page":40,"issue_id":620331}

HABs are problematic in all 50 US states. 54% of TP comes from domestic human waste and agriculture contributing 38%. Alternatives include advanced gasification, pyrolysis, varcor processing, omni processing, supercritical water oxidations, and nutrient recover. Utilities to land-applied biosolids costs between $50 to$200 per dry ton. Cost of removing nutrients from surface waters using STAs is $36 per lb for TN and $130 per lb for TP.

Roderick, G. (2018). Florida TMDLs and Biosolids. Web. PowerPoint.

81% of Florida's nitrogen and 89% of Phosphorous fertilizer consumption (tons) in Farms. BMP implementation provides protection under the Florida Right to Farm Act from duplicative local regulation. No sites with decreasing trends in any TMDL parameters (2006-2015). About 12% of TN and TP imports end up in surface waters. TN migrates towards surface waters while TP stays "attenuated" near the drain field. 200,00 dry tons of Class AA biosolids and 100,000 dry tons of Class B. Class AA biosolids concentrated in South Florida. Cost per pound to remove TP in agricultural and rural areas averages to $130/lb and $26/lb for TN. Cost in urban areas average to $5,888/lb for TP and $2,007/lb for TN. Alternative solutions are recommended including increased urban and regional water attenuation, converting failing septic systems to central sewer, and increased attenuation of water and increased fertilizer "efficacy" in agriculture.

Spear, K. (2018). Rare Florida jewel, Blue Cypress Lake, sickens with pollution. Orlando Sentinel. Web. http://www.orlandosentinel.com/news/os-blue-cypress-sewage-pollution-20180405-story.html

In a state of nearly 2,000 small and large plants treating household sewage, the city of Orlando alone pays about $3 million annually to get rid of its sludge as a low-cost agricultural fertilizer. Biosolid impacts being observed in Blue Cypress. Water supply needs in upper St. Johns River for a growing population. That water supply was significantly protected by a $250 million restoration of the river's headwaters.

Environmental Impacts

Hamid, H. & Li, L. (2016). Role of Wastewater Treatment Plant in Environmental Cycling of Poly- and Perfluoroalkyl Substances. Ecocycles (2) 43-53.

PFOS and PFOA most frequently detected in wastewater. Urbanized areas contain higher concentrations. Advanced biological treatment with nutrient removal results in highest removal efficiencies. PFCA, PFSA, and FOSA detected in sewage sludge. Anerobic and aerobic digestion/incineration increases the concentration of PFAAs compared to untreated sludge. WWTP effluent is a major source of PFAAs in surface water and these chemicals increase with increasing trophic level in the food chain in riverine ecosystems. Land application shows bioaccumulation of

short chain PFAAs in various plant compartments, leading to possible contamination of the food cycle. Elevated air concentrations of PFACSs reported at aeration tanks on WWTP sites.

Lu, P., & O'Connor, G.A. (2001). Biosolids Effects on Phosphorus Retention and Release in Some Sandy Florida Soils. Journal of Environmental Quality (30) 1059-1063.

Biosolids applied to land at rates based on crop N needs frequently supply P far in excess of crop removals, and can cause P accumulations that endanger nearby water supplies. Study finds that biosolids additions to Florida soils had little effect on P retention in a soil with abundant oxalate-extractable Fe and Al and a correspondingly large native P-sorbing capacity. Biosolids significantly increased P retention in a soil with low oxalate-extractable Fe and Al content and low native P-sorbing capacity. Effects lasted 1 to 3 years after application depending on biosolids source and rate of application. Disappearance of added Fe and Al concentrations from the surface horizons over time was relatively rapid, perhaps due to abundant organic acid production associated with biosolids degradations. P in biosolids containing abundant Fe and/or Al can be expected to behave as a slowly available P source, and less subject to leaching losses than completely soluble P sources.

Lu. Y., et al. (2019). Biosolids and Biochar Application Effects on Bahiagrass Herbage Accumulation and Nutritive Value. Agronomy Journal (112) 1330-1345.

Pastures represent the major cropping system where biosolids are recycled in Florida. Perennial pastures are good candidates for receiving biosolids because of their high nutrient requirements and their roots capture nutrients and minimize off-site nutrient transport. Bahiagrass total annual herbage accumulation was similar for biosolids and inorganic fertilizer treatments in 2017 (inorganic fertilizer/aerobically digested Class B biosolids increased total annual herbage accumulation ~29% relative to other sources in 2018). Biosolids and inorganic fertilizer increased bahiagrass crude protein concentration ~22% and ~39%, respectively compared to unfertilized treatments. Biosolids resulted in greater IVDOM than inorganic fertilizer. No benefit of biochar on bahiagrass responses.

St. Johns River Water Management District. (2018). Patterns in Surface Water Phosphorus Concentrations and Biosolids Utilization in the Upper St. Johns River. PowerPoint.

11 of 36 WQ sites exhibit increasing TP trend (Blue Cypress Lake: Increasing Chlorophyll a). Increased incidence of Microcystis in Class 1 waters. 31 segments impaired or "4d." Land use in major western watersheds of the USJ is mostly Pasture/Range (~60%) followed by Forest/Undeveloped. (~40%). General agriculture/groves and Residential/commercial/industrial <10%. Some sites show the application of biosolids up to 20 years. Class B biosolids produced at 42 generating facilities (89% outside district) were land applied in the USJRB in 2017 (3 facilities land applied >5000 dry tons). 136,155 acres of biosolids application areas in Upper St. Johns (`12% of entire area). Applying 5-10 times the crop TP need. Altogether there is a strong relationship between cumulative biosolids application and TP concentrations indicated by paired watershed changes in water quality. No other sources of P loading and no evidence of land use driven changes. Upper basin is Class I waters and increased P can threaten water source and impact habitat conditions, recreations, and aesthetics to a $250M USACOE and District restoration project.

Sepulvado, G. et al. (2011). Occurrence and Fate of Perfluorochemicals in Soil Following the Land Application of Municipal Biosolids. Environmental Science & Technology (45) 8106-8112.

This study evaluates the levels, mass balance, desorption, and transport of PFCs in soils receiving application of municipal biosolids at various loading rates. PFOS was the dominant PFC in both biosolids and biosolids-amended soil. Concentrations of all PFCs in soil increased linearly with increasing biosolids loading rate. Study also indicates the potential transformation of PFC precursors. The leaching potential of PFCs decreases with increasing chain length. Trace levels of PFCs were also detected in soil cores from biosolids-amended soils to depths of 120 cm, suggesting potential movement of compounds over time and confirming the higher transport potential for short-chain PFCs in soils amended with municipal biosolids. While PFCs are known to be present in municipal biosolids, it remains unclear whether the application of typical municipal biosolids to agricultural soil could pose any potential PFC-related risks for human and ecological health. No soil concentrations measured in this study exceeded the residential soil screening guidance values, which were designed for protection against direct exposure to soil. However, soil screening standards for the protection of groundwater have not yet been developed; therefore, it is illustrative to calculate whether measured soil concentrations have the potential to lead to groundwater exceedances of the PHAs for PFOS and PFOA. Calculations indicate the PHA for PFOA would be exceeded in the short-term W pore water at loading rates of 89 and 178 Mg/ha and in the short-term K pore water at 44 and 133 Mg/ha. Soil pore-water PFOS concentrations would also exceed the PHA in Soil K plots at 44 and 133 Mg/ha.

Sharma, B., et al. (2017). Agricultural Utilization of Biosolids: A Review on Potential Effects on Soil and Plant Growth. Waste Management (64) 117-132.

Global waste generation is associated with increasing urbanization and increasing GDP. Currently, there is limited capacity for sewage treatment. The principles of waste management hierarchy points towards agricultural recycling of biosolids as a more environmentally preferred option over traditional disposal methods (incineration, soil application, land filling, and sea dumping). Biosolids are beneficial for N and P but there are seasonal and treatment process induced variations (aggregate stability, bulk density, porosity, and water retention), toxic heavy metals, and pathogenic bacteria. Biosolids can improve the physical properties of soil (increasing water holding capacity, forming stable organic heavy metal complexes, and reducing metal availability in contaminated soil) and increase plant productivity. Chemical properties depend on soil-sludge properties, rate of application, interaction, and soil pH. Biosolids can also be used to manage leaching nutrients and heavy metals that can spread to plants or groundwater. Long-term land depositions can cause accumulation of toxic elements and their transfer to the food chain on diverse trophic levels. Author recommends commercial production to replace commercial fertilizers with stringent and persistent monitoring.

Stepzinski, T. (2018). FWC Investigating Mysterious Freshwater Turtle Die-Off. Ocala StarBanner. Web. http://www.ocala.com/news/20180531/fwc-investigating-mysterious-freshwater-turtle-die-off

Freshwater turtles are dying throughout the St Johns River watershed (Putnam, Orange, and Seminole Counties). At least 100 dead. Occurring in other regions as well. Primarily Florida softshell turtles/river cooters (indicator species). Possible respiratory impacts from sewage sludge.

Waymer, J. (2018). Cancer-Causing Compounds Found in Alligators, Dolphins, Wildlife at Kennedy Space Center. Florida Today. Web.

https://www.floridatoday.com/story/news/local/environment/lagoon/2018/08/24/cancer-alligators-dolphins-kennedy-space-center/934923002/

Toxic compounds (fluorinated chemicals) from firefighting foams are present in local food chain and groundwater (Satellite & Cocoa Beach). Apex predators have higher concentrations. Possible link to spike of cancer reports on Space Coast over five decades. Linked to chemical waste from Space Race and US military training (DDT, PCBs, and TCE). Compounds not regulated. Local water systems tested clean. Impacts exacerbated when algae blooms occur. Compounds associated with sewage. Budget constraints and novelty of contaminants stalled monitoring and research.

Potential Health Impacts

Jones-Lepp, T. L., & Stevens, R. (2007). Pharmaceuticals and Personal Care Products in Biosolids/Sewage Sludge: The Interface Between Analytical Chemistry and Regulation. Anal Bioanal Chem (387) 1173-1183.

This paper investigates whether pharmaceuticals are present in WWTP-produced sewage sludge, summarizes current regulatory practices regarding sewage sludge, and reports on the presence of pharmaceuticals in sewage sludge. Studies found aspirin, caffeine, methaqualone, and methotrexate in sewage effluent, and source waters. Galaxolide, Tonalide, nonylphenols, alkylphenols, tetracycline, fluoroquinolones, synthetic musks, etc. found in sewage sludge. Study found three pharmaceuticals in Class A and B biosolids and thirteen pharmaceuticals at varying amounts. Three macrolides detected in Milorganite (roxithromycin, azithromycin, and clarithromycin. Each sewage sludge material will have unique analytical challenges that will need to be addressed before final chemical signatures can be assigned and determinations can be made on bioavailability and environmental impact of pharmaceuticals due to major chemical differences in sewage sludge products and varying regulations and treatment processes. Disposal of unused pharmaceuticals , either by household waste or via the sink or toilet may be a prominent route to the environment that requires greater consideration. With respect to pollutants in sewage sludge, particularly emerging contaminants such as PPCPs, more accurate data on use, advances in chemical analytical methodology, survival efficiencies in wastewater treatment facilities, environmental fate and transport, and the potential for effects in humans and the environment will be required to conduct reliable exposure and hazard assessments.

Pandopulos, A.J. et al. (2021). A Method and its Application to Determine the Amount of Cannabinoids in Sewage Sludge and Biosolids. Environmental Science and Pollution Research (28) 59692-59664.

Xenobitic cannabinoids shown to accumulate within the particulate fraction of wastewater. Three cannabinoids were abundant in primary sludge including THC, THC-COOH, and CBD (THC concentrations up to 3200 ug kg-1). Detection of cannabinoids in biosolids demonstrates that these compounds are stable throughout the treatment process. Sewage sludge and biosolids have been shown to contain the bulk of phytocannabinoids. Public health concern on cognitive function, anxiety, panic reactions, schizophreniform, manic, and confusional psychoses. Cannabinoids incorporating synthetic substances to avoid legislation or to enhance effect pose risks including tachycardia, syncope, seizures, and death in users, and makes monitoring difficult. Phytocannabinoids, being the most widely abused illicit substances, may pose long-term environmental risk if they persist after sewage treatment or are transformed into hazardous by-

products. Exclusive targeting of the solid fraction could result in improving accuracy of substance use.

Perkins, T. (2019). Biosolids: Mix Human Waste with Toxic Chemicals, then spread on crops. The Guardian. Web. https://www.theguardian.com/environment/2019/oct/05/biosolids-toxic-chemicals-pollution

Americans send about 300m pounds of feces to wastewater treatment plants. About 60% of sewage sludge produced by treatment facilities will be spread on farmland and gardens, schoolyards, and lawns. Sludge is mixed with 80,000 manmade chemicals discharged from industry's pipes. Burning of sludge banned by federal government. EPA estimate more than 350 pollutants in biosolids but only 9 are regulated. Lack of data on safety of pollutants. North Carolina study found 75% of people living near farms that spread biosolids experienced health issues. Other studies indicate impacts on cows, water quality, and air pollution. PFAs in biosolids linked to more serious health problems. Well contaminations and air pollution. No testing on PFAs due to economic impacts on agricultural industry.

Treadway, T. (2017) Ohio State University study links toxic algae blooms, fatal liver disease. TCPalm. Web. http://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2017/05/22/ohio-state-university-study-links-toxic-algae-blooms-fatal-liver-disease/100971180/

"People living in areas with significant blue-green algae blooms, including the Treasure Coast, are more likely to die from nonalcoholic liver disease than those who don't." In fact, the death rate from liver disease not related to alcohol was nearly twice as high in the four counties (Martin, St. Lucie, Indian River, and Okeechobee) as the national rate during the 12 years of the OSU study. Liver disease can have numerous causes besides chronic alcohol use, including genetics, cancers, obesity, parasites, and viruses, such as hepatitis viruses. "Along with drinking it in water and eating in food, breathing it in is the most effective way for the toxins to enter your body," Also recommended not using algae-rich water for irrigation.

Treadway, T. (2019). Hepatitis A Outbreak: Is There a Link to Biosolids That Farms Spread to Fertilize Fields? TCPalm. Web. https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2019/04/17/hepatitis-outbreak-there-link-biosolids-farms-spread/3477020002/

Virus is spread by food or water contaminated by fecal matter. Highest concentrations of biosolids and the virus in Florida. 10/811 fatal cases. 3 in Martin County. Biosolid chlorination process kills hepatitis A (not all). Virus found in biosolids spread on farmland. Biosolids contain 352 pollutants. Hepatitis A not monitored by EPA. Hepatitis A concentrated near Biosolids locations in central Florida. Cannot get the virus from eating food.

Waymer, J. (2019). Sewage Sludge Central? Officials Fear Waste from Other Communities Threatens Water Supplies. Florida Today. Web. https://www.floridatoday.com/story/news/local/environment/2019/07/29/central-florida-sludge-central/1829885001/

South Florida sewer plants exporting sewage remnants. Deadly neurotoxin found in Lake Washington and Indian River Lagoon (Saxitoxin). WMD spent $260 million and three decades to re-engineer St. Johns River. TAC recommends minimizing N and P, stricter sludge application rates, and stepped-up inspections.

Surface Water Impacts

Algae World News. (2018). HUMANS ARE OVERLOADING THE WORLD'S FRESHWATER BODIES WITH PHOSPHORUS. Web. http://news.algaeworld.org/2018/02/humans-are-overloading-the-worlds-freshwater-bodies-with-phosphorus/

Freshwater bodies around the Earth are overly enriched with phosphorus. "Sewage, agriculture, and other human sources add about 1.5 teragrams of phosphorus to freshwaters each year." "Phosphorus in human waste was responsible for about 54 percent of the global load, while agricultural fertilizer use contributed about 38 percent (7 percent contributed by U.S.)." "In 38 percent of these basins, WPL is greater than one, indicating an excess of phosphorus."

Brevard County. Brevard County Sampling Report for the Land Application of Biosolids on Deer Park Ranch and Other Potential Impacts to Lake Washington Water Quality. Applied Ecology.

Toxic Algal bloom in Lake Washington in 2019. No samples exceeded drinking water standards for metals. Highest TN values observed in Lake Washington (not exceeding NNC). Highest TP observed in waters flowing off the ranch (above NNC). Low TN to TP ratio at Deer Park Ranch. PFOS concentrations exceeding screening levels at site east of Lake Washington. Quantifiable concentrations of PPCPs at Deer Park Ranch.

D'Angelo, C. (2019). Sun, Sand, and Sewage: Report Shows Many U.S. Beaches Unsafe for Swimming. HuffPost. Web. https://www.huffpost.com/entry/beaches-water-contamination-2019-report_n_5d3649f4e4b0419fd331c40e

Report highlights 29 states with degraded beach quality associated with high levels of bacterial contamination from urban runoff, sewage overflows, and industrial livestock.

Garcia, J. (2018). Biosolids: Waste to Fertilizer to – Pollution. Florida Trend. Web. https://www.floridatrend.com/article/25908/biosolids-waste-to-fertilizer-to--pollution

Toxic Blue-green algae found in Blue Cypress Lake even though development is limited. Toxins exceeding levels safe for human health. Biosolids being applied on ranch nearby. Pharmaceuticals linked to biosolids due to short half-life. Population growth issues. St. Johns River WMD indicates longterm trends of phosphorus growth. Indian River, Osceola, and Brevard counties account for ¾ of class B biosolids permitted statewide (many cattle pastures). Cheap fertilizer and economic benefits to transport industry.

Gramling, C. (2018). Humans are Overloading the World's Freshwater Bodies with Phosphorus. Science New. Web. https://www.sciencenews.org/article/humans-are-overloading-worlds-freshwater-bodies-phosphorus

Freshwater bodies on 38% of Earth's land area are overly enriched with phosphorus resulting in toxic algal blooms and less available drinking water. Sewage, agriculture, and other human sources. Phosphorus in human waste accounts for 54% and agriculture 38% of global load.

Janicki, T. (2018). Nutrient Loading in Florida Estuaries. Web. PowerPoint.

Loading sources range from point sources, nonpoint sources, groundwater/baseflow, atmospheric deposition, and biosolids. Watersheds evaluated include Charlotte Harbor Estuary, Sarasota Bay Estuary, Tampa Bay Estuary, Mosquito Lagoon, and Indian River Lagoon. Nonpoint sources are the largest contributors to TN and TP loadings in Tampa Bay and Charlotte Harbor. Direct runoff is the

largest contributor to TN and TP loadings in Sarasota Bay. Baseflow and runoff are the largest contributors to TN and TP loadings in Indian River Lagoon and Mosquito Lagoon.

Roderick, G. (2019). Nutrient Impacts to Florida Surface Waters (DRAFT): A Comprehensive Approach for Nutrient Impacts to Surface Waters from Agriculture and Domestic Human Waste.

In Florida, 53% of is rivers, 82% of its lakes and reservoirs and 32% of bays and estuaries are impaired by nutrients, specifically, total phosphorus (TP) and total nitrogen (TN). Septic tank systems normally do not contribute TP to surface waters. TN if septic system is failing. Some WWTFs still permitted to discharge directly into the ocean. Class AA and Class B Biosolids contain about 5-9% of TN and 2-5% TP. Impacts of categorization of pollution sources (need comprehensive approach). Solutions include converting failing septic systems to central sewer, proper maintenance, repair and replacement of conveyance system. Florida produces about 350,000 dry tons of biosolids annually. Production increasing. 100,000 dry tons disposed in landfills. 110,000 dry tons regulated and land disposed as Class B. 140,000 dry tons of Class B converted to Class AA. 55,000 dry tons of Class AA contributing over 1,200 tons of TP annually to Lake O'. Most disposed on pastures. Bahia grass produces well without P fertilization. 23-57 years to flush legacy P. Agriculture reached efficacy limits of implementing voluntary agricultural BMPs. Only alternative is alternative technologies (gasification, pyrolysis, etc.). $50 to $200 per dry ton to land apply biosolids.

USA Today Editorial Board. (2019). Turning the Toxic Tide: Florida Must Address the Problem of Human Waste. Florida Today. Web. https://www.floridatoday.com/story/opinion/2019/03/27/turning-*toxic-tide-florida-must-fix-septic-sewer-and-biosolids/3084306002/*

Est. 2.6 million septic tanks in Florida and no inspection requirement. Up to 40% of significant nutrients can be removed by a properly functioning septic. Water quality impacts from failing infrastructure and storm damage (sewage pipes, pump stations, and treatment facilities). Good infrastructure and septic to sewer conversions alone are not enough to fix the problem. Biosolids impacts creating bigger problem.