Implement Integrated and Sustainable Materials and Waste Management Practices

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Table of Contents

Solid Waste

Baseline

The San Juan Bay Estuary (SJBE) region produces 31% of the island's waste, but only accounts for 8% of the land area (Estuario, 2022). However, a recent Department of Natural and Environmental Resources (DNER) study showed a reduction in daily waste generation to 4.9 pounds per person (Geosyntec, 2024). While solid waste management is improving, this is a major issue in the SJBE watershed that requires planning, infrastructure, education, and enforcement to reduce waste generation, illegal dumping, and provide improvements in waste reduction and recycling in the watershed.

The Puerto Rico Solid Waste Authority Act of 1978 (Law No. 70) created the Puerto Rico Solid Waste Management Authority (SWMA). SWMA adopted the Solid Waste Management Authorities regulations following the passing of Law No. 70 of September 18, 1992, as amended, known as "Law for the Reduction and Recycling of Solid Wastes in Puerto Rico." This law promoted the reduction, reuse, and recycling of waste. These regulations required the development and implementation of recycling plans by the municipalities, agencies, and private entities. One chapter required the separation of all recyclable materials from sanitary landfills, and established administrative penalties for the violations of the prohibition against disposing recyclable materials. In 2018, Law No. 171, the act to implement the "Department of Natural and Environmental Resources Reorganization Plan of 2018," was adopted and repealed Law No. 70 of 1978 and moved SWMA into DNER.

In 2014, Puerto Rico passed Law 114-2014: Law for the Use of Recycled Materials in Public Infrastructure of the Commonwealth of Puerto Rico. This law referenced multiple studies that concluded that the use of recycled concrete and asphalt products improved the performance of the finished product while at the same time reducing the construction costs. The law required that recycled materials be used in public construction projects. Specifically, reclaimed asphalt is to account for 20% of asphalt used in paving projects. The law also mandated a percentage of recycled materials to be used on concrete construction projects. The law addressed used tires by providing mandating that playgrounds, athletic tracks, and safety barriers be constructed with recycled tires. Like concrete, the law set forth a mandate to establish a percentage of recycled tire materials to be used on these projects.

The Puerto Rico Climate Change Mitigation, Adaptation and Resilience Act of 2019 (Law 33-2019) and subsequent revisions targeted a waste reduction to Puerto Rico landfills of 60% by 2030. This goal reduces the amount of waste in the system and to the estuary, reduces the number of landfills to be retrofitted and/or built, and results in a significant saving on energy in fuel used to collect and process the waste, which also reduces greenhouse gases from fuel consumption and landfill emissions. The development and implementation of formal solid waste management and recycling plans within SJBE municipalities has and will continue to greatly reduce the amount of waste that enters the SJBE system. Reducing solid waste will improve the quality of life for local residents, improve the estuary's environmental quality, and reduce marine wildlife injury and mortality related to ingestion of or entanglement with aquatic debris (Estuario, 2022).

Municipal ordinances, such as the 2023 Public Order Code of the municipality of San Juan have also been adopted. Included in this ordinance are waste management and environmental requirements, such as anti-littering rules, placing recycling materials in containers, bundling vegetative debris, and storing general

waste in secured containers, to provide a neat appearance and eliminate the scattering of debris. The ordinance also established enforcement, including fines for violations.

Estuario prepared the Analysis and Recommendations for the Integrated Management of Resources and Waste in 2022, which outlined a systematic approach to achieve the goal of eliminating aquatic waste and improving habitat quality. This report identified alternatives and strategies to strengthen the existing opportunities between the municipalities by evaluating the infrastructure, capacity, management, and disposal of waste and resources at the watershed basin level. A total of six actions were proposed including: (1) improving collaborative efforts to compile the same information and metrics; (2) creating intentional collaboration between the municipalities of the basin; (3) implementing strategies to detect, correct ,and control point and nonpoint discharges; (4) increasing compliance of recycling plans of municipal governments; (5) reinforcing recycling and correct disposal of materials and resources, and (6) promoting a culture that promotes the correct management of waste, among others.

Based on these recommendations, Estuario formed an Inter-Municipal Network in 2023. The Network allows effective communication between the municipalities to identify financing at the federal level and other programs that meet the identified needs. Municipalities also share best management practices and plan and fund efforts to address illegal dumping, manage used cooking oil, compost organic waste, and recycle tires, replicating initiatives across the watershed. Another effort is the creation of a comprehensive waste management plan at the watershed basin level that aims to provide a guide that would facilitate and maximize the use of their resources.

Moreover, Estuario developed a website that provides a map (see Figure 1) with materials collection centers across the watershed. This map allows the user to search facilities by materials collected (https://estuario.org/centros-de-acopio/) and offer other waste management opportunities.

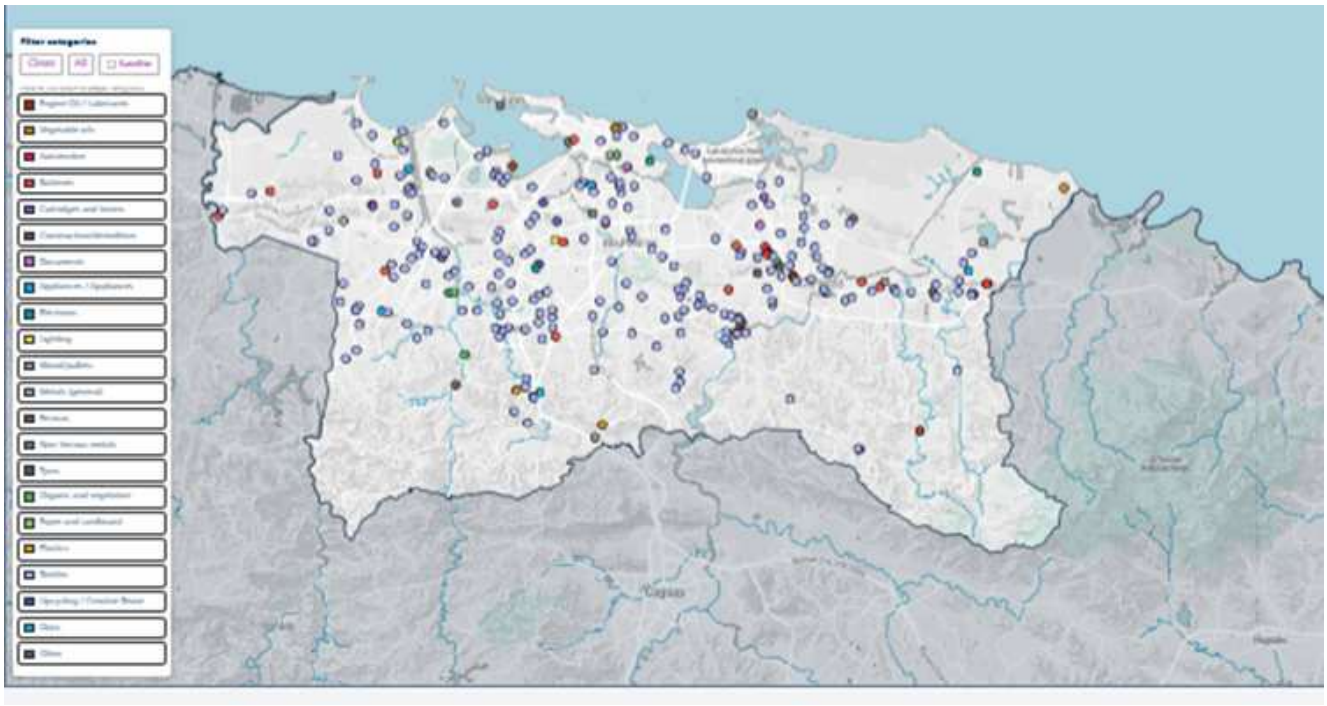

Figure 1. Placeholder map from Centro de acopio y manejo de materiales a traves de la cuenca del Estuario

DNER published a Solid Waste Characterization study in 2024 to evaluate the waste stream in 78 municipalities in Puerto Rico and evaluate the effectiveness of the waste reduction practices. The study showed a reduction in daily waste from 5.18 pounds per person per day in 2003 to 4.9 pounds per person per day. Compounded by a decrease in population, a waste reduction of 21.4% was calculated. While an overall decrease was observed, increases in plastics, metals, and municipal solid waste were observed. An increase in lined landfills from 53% to 80% was also observed, suggesting significant improvement to the protection of groundwater. Tourism and urbanization can increase waste generation near coastal areas, which can directly affect the amount of aquatic debris. (DNER, 2024).

In 2023, the National Oceanic and Atmospheric Administration (NOAA) and U.S. Environmental Protection Agency (USEPA) developed the 2023–2028 Puerto Rico Strategic Plan to Reduce Aquatic Debris. The plan focused on the goals of prevention, removal and disposal, and emergency response to aquatic debris and coordination with local stakeholders to implement the plan. Plan partners developed actions associated with these goals to improve reduction, reuse, and recycle models and, subsequently, prevent the overall waste available to enter the water. This included the creation of a work group with emphasis on eliminating single use plastics. Through the Strategic Plan, stakeholders are also capable of planning ahead to address other types of debris and navigate through the challenges.

More frequent and severe storms make waste management on land more critical, as these storms can lead to significant waste and debris in the water from uncontained waste in the watershed. The cost of waste removal is a challenge that is magnified once waste enters the water and further magnified once waste sinks to the waterbody floor. The general waste and debris in the water can affect wildlife and habitat both by its presence and removal. This is of particular concern with regard to derelict vessels and fishing gear around sensitive habitats, such as corals. The NOAA Marine Debris Program and USEPA Trash Free Waters Program provide technical support and grant funding for the management of aquatic debris; however, funding is limited (NOAA and USEPA, 2023).

Objectives

- Reduce the amount of solid waste generated.
- Significantly increase the percentage of materials recycled.

Actions

WM-01 Develop and implement community-based waste management in coordination with municipalities. Adaptation

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Ensure that the eight municipalities in the estuary's drainage basin develop Solid Waste Management and Recycling Plans as required by Law No. 70, Municipal Code of Puerto Rico.	Include measures to mitigate the major problems with solid waste management, aquatic debris, and illegal dumping in the SJBE.	Created municipal plans and DNER compliance plans with notices of violation and penalties, for municipalities that have not developed plans.	Lead: Municipalities Implementing partners: DNER, Estuario, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities
2. Determine specific waste management and recycling strategies for identified critical areas where large amounts of aquatic debris are found ("hot spots").	Identify deficiencies in the waste management services provided by local governments and deficiencies in enforcement of solid waste disposal laws.	Identified critical areas and implemented strategies.	Lead: Municipalities Implementing partners: DNER, Estuario, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
3. Launch an educational campaign stressing the importance of the SJBE system and need to establish and support effective solid waste management and recycling initiatives.	Include information about the connection between the estuary system and local areas and promote community-based solid waste management and recycling programs.	Launched educational campaign.	Lead: Estuario Implementing partners: DNER, municipalities, Puerto Rico Tourism Company, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, U.S. Department of Agriculture (USDA), municipalities
4. Assist and support local communities in the development of waste management and recycling programs designed to meet their needs.	Identify recyclable materials, determining when, where, and how the material will be collected, and coordinate material transportation to recycling centers.	Established waste management and recycling programs.	Lead: Municipalities Implementing partners: DNER, Estuario, private waste management and recycling companies, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, USDA, municipalities

5. Conduct regular monitoring and evaluation of waste management and recycling activities in each community.	Recycling data gathered related to quantity of materials collected, reused, or recycled, type of material, transportation costs, and final disposal.	Created a unified digital data platform for waste tracking and public access with quarterly reports submitted to SWMA's Recycling Division.	Lead: Municipalities Implementing partners: Estuario, DNER, private waste management and recycling companies, community groups	Ongoing	5+ years	TBD	USEPA, DNER, municipalities

Regulatory and Policy Requirements

Enforcement of Law No. 70 of 1992, which requires the development of Municipal Solid Waste Management and Recycling Plans, and the Municipal Code of Puerto Rico by DNER is required.

WM-02 Conduct periodic clean-up activities at suggested SJBE locations. Adaptation

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Launch an educational campaign stressing the importance of the SJBE system to mobilize volunteers and sponsors for cleanup activities.	Increase awareness of the natural and recreational values of the SJBE system.	Completed campaigns to increase the public awareness of keeping the SJBE system trash free.	Lead: Municipalities Implementing partners: Estuario, DNER, community groups	Ongoing	3-5 years	TBD	DNER, municipalities
2. Organize debris clean-up events at suggested SJBE sites and encourage local volunteer groups with their own independently organized clean-ups at SJBE locations.	Reduce the amount of trash and debris in the SJBE system.	Held and supported local debris clean-up events.	Lead: Municipalities Implementing partners: Estuario, DNER, community groups	Ongoing	0-2 years	TBD	DNER, municipalities

Regulatory and Policy Requirements

None.

WM-03 Establish solid waste pollution prevention initiatives at different SJBE locations. Adaptation

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Identify generation hotspots and deficiencies in the waste management services provided by local governments in the vicinity of known hotspots in commercial areas.	Identify deficiencies in the waste management services provided by local governments in the vicinity of hot spots and enforce solid waste disposal laws.	Critical areas identified, and strategies implemented.	Lead: Municipalities Implementing partners: Estuario, DNER, community groups, Department of Community Affairs, Puerto Rico Aqueduct and Sewer Authority (PRASA)	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
2. Design and implement initiatives for each identified hotspot using the replicable model established in the *Strategic Model for Waste Management* and in close collaboration with communities.	Create initiatives and develop implementation plans to reduce solid waste pollution.	Developed and sustained action plans using information about community characteristics.	Lead: Municipalities Implementing partners: Estuario, DNER, community groups, Department of Community Affairs, PRASA	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA

Regulatory and Policy Requirements

These initiatives are efforts to educate and support the existing laws. At the local level, ordinances for waste diversion and recycling are necessary, as well as increased enforcement.

WM-04 Implement measures to enforce Puerto Rico's waste management laws including the Anti-Littering Law (Law 10-1995) and the Law for the Management of Used Tires (Law No. 41).

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify needs and opportunities to improve enforcement of the waste management laws in close collaboration with communities.	Collaborate among government, private sector, non-governmental organizations, and citizens with an emphasis on planning, funding, and infrastructure.	Increased efficiency and enforcement.	Lead: Municipalities Implementing partners: Estuario, DNER, USGS, U.S. Coast Guard (USCG), community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
2. Evaluate effectiveness and propose policy recommendations to better manage litter.	Improve enforcement of Law 10-1995 through implemented initiatives.	Evaluated enforcement actions and collection and disposal data and report quarterly.	Lead: Municipalities Implementing partners: Estuario, DNER, USGS, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA

3. Identify existing illegal used tire dumping grounds within the SJBE drainage basin and waterbodies.	Inventory of the number of discarded tires, identify critical areas with inadequate used tire disposal, prioritize mitigation activities, and study the need and feasibility of removing the used tires at the bottom of San Juan Bay Harbor.	Developed a detailed Action Plan for effective tire removal.	Lead: DNER Implementing partners: Municipalities, Estuario, U.S. Coast Guard (USCG), tires centers and transportation companies, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
4. Evaluate deficiencies in the management and disposal processes for used tires and, if possible, identify which entity is responsible for inadequate/illegal disposal practices.	Update the inventory of registered tire establishments in each municipality and conduct an investigation to identify those which are not registered.	Inventory and registration completed.	Lead: DNER Implementing partners: Municipalities, Estuario, USCG, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
5. Launch an educational campaign stressing the need to establish and support effective used tire management and recycling initiatives.	Increase awareness of communities regarding the risks related to the inadequate disposal of used tires and the proper notification channels.	Support from local communities serve to inform local authorities of illegal dumping activities.	Lead: DNER Implementing partners: Municipalities, Estuario, USCG, community groups	Ongoing	3-5 years	TBD	USEPA, DNER, municipalities, NOAA

Regulatory and Policy Requirements

At the local level, ordinances for waste diversion and recycling are necessary, as well as increased enforcement. Municipalities should prepare and enforce compliance plans to ensure that Law 41-2009 is followed and that responsible authorities respond to reported incidents in a timely fashion.

**NEW* WM-05 Eliminate Illegal Dumps Across the Region.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify the locations of illegal dumps and create a georeferenced database that communicates with the reporting platform.	Review collection and disposal data to identify illegal dumps and the materials being dumped.	Created a unified digital data platform for waste tracking and public access with quarterly reports submitted to DNER's Recycling Division.	Lead: Municipalities Implementing partners: Estuario, DNER, USGS, community groups	Pending	3-5 years	TBD	USEPA, DNER, municipalities, NOAA, USDA

2. Design, implement , and adapt initiatives based on Estuario's strategic model for integrated management of resources and waste.	Increased collaboration among government, private sector, non-governmental organizations, and citizens and emphasize planning, funding, and infrastructure.	Reduced illegal dump sites across each community and increased reuse, diversion, and recycling of solid waste.	Lead: Municipalities Implementing partners: Estuario, DNER, USGS, community groups	Pending	5+ years	TBD	USEPA, DNER, municipalities, NOAA, USDA

Regulatory and Policy Requirements

Regulations may need to be modified to properly close illegal dumps throughout the watershed.

References

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Estuario. 2022. Analysis and Recommendations for the Integrated Management of Resources and Waste in Puerto Rico.

Estuario. 2024. Strategic Model: Campaign "That it does not touch the ground or reach the water." (April 2021 – April 2024).

Geosyntec Consultants. 2024. Final Report Solid Waste Characterization Study Puerto Rico. Prepared for: Government of Puerto Rico and Department of Natural and Environmental Resources. FINAL_ME2199_DNER+SWCS_Final+Report__01_30_24.pdf.

NOAA and USEPA. 2023. 2023-2028 Puerto Rico Strategic Plan to Reduce Aquatic Debris. Silver Spring, MD: National Oceanic and Atmospheric Administration Marine Debris Program.

Fats, Oils, and Greases

Baseline

Fats, oils, and greases (FOGs) encompass a variety of substances derived from both animal and plant origins and are frequently generated in residential kitchens and commercial food service establishments. These materials can severely compromise wastewater systems if not managed properly. In addition to FOGs, petroleum-derived oils, fats, and sediments from automotive services, collectively referred to as petroleum oils, greases, and sediments (POGS), also contribute significantly to the pollution challenges faced by the SJBE. These pollutants, when introduced into the wastewater system, can lead to blockages, overflows, and increased maintenance costs, ultimately affecting the local environment and communities (PRASA, 2024a).

The management of FOGs and POGS is governed by stringent regulations established by USEPA, specifically under 40 Code of Federal Regulations Part 403. This regulation mandates PRASA to implement a control program for fats and greases aimed at preventing the discharge of solid or viscous pollutants that can clog sewage systems. PRASA's program for the control of oils and greases, implemented through Regulation 6685 (Rules and Regulations for the Supply of Water and Sewer Service) requires commercial, institutional, and industrial users that discharge wastewater containing FOGs or POGS to install and maintain proper control equipment, such as grease traps, interceptors, or separators, which are designed to manage these waste streams effectively (PRASA, 2024b).

Routine inspections are fundamental to ensuring compliance with these regulations. PRASA conducts routine inspections under their programs and may issue notifications of noncompliance, administrative penalties, and pursue legal action where appropriate (PRASA, 2024c). PRASA also systematically conducts inspections of food service establishments to verify adherence to legal guidelines. These inspections cover several critical areas, including the functionality and accessibility of grease control equipment, proper disposal methods for oils classified as "yellow grease" (viable for recycling) versus those qualifying as "brown grease" (waste generated from cleaning grease control equipment), and prevention of spills that may lead to FOG accumulation in the environment. Establishments are also required to implement best management practices, such as having designated spill control plans, posting clear signage indicating "Do Not Pour Grease," and installing screens over sinks and floor drains to prevent the entry of food residues (PRASA, 2024).

Among the pressing challenges faced by municipalities is that approximately 60% of sanitary sewer overflows can be attributed to improper handling of used cooking oil (Generacion Circular, 2021; Estuario, 2025a). Community involvement plays a pivotal role in addressing these challenges associated with FOGs in the SJBE. Estuario has initiated several educational campaigns to raise awareness about the importance of responsible waste management and its benefit on aquatic ecosystems. One notable initiative is the "Que no toque el piso ni llegue al agua" (That it does not touch the ground or reach the water) campaign, which focuses on promoting responsible solid waste practices within communities. This initiative has successfully diverted significant amounts (629 pounds of oils) from infiltrating storm sewers, thereby reducing potential long-term environmental damage (Estuario, 2025a). The success of these programs underlines the necessity for continual community and stakeholder engagement in waste management strategies (Estuario, 2025b).

In tandem with these initiatives, the campaign "Deja una huella limpia en Piñones" (Leave a Clean Footprint in Piñones) serves as a rallying call to local residents and businesses for the protection of coastal ecosystems by reducing solid waste generation and promoting responsible disposal practices. Inspired by

the principles underpinning the "Que no toque el piso ni llegue al agua" campaign, this effort addresses waste reduction within the commercial, tourism, and residential sectors. Participating businesses are encouraged to adopt environmentally responsible practices, such as recycling used cooking oils and using compostable materials. (Leave a Clean Footprint, 2023).

PRASA's compliance measures involve regular assessments of grease control equipment at establishments to ensure that they meet the outlined standards. Significant emphasis is placed on proper documentation of equipment maintenance and disposal methods to validate compliance. In instances where violations are discovered, PRASA has protocol for enforcement that may include notifications, penalties, and legal actions to ensure that responsible practices are upheld.

Looking ahead, ongoing efforts within the framework of the control program for FOG and related community initiatives will be pivotal in safeguarding the SJBE and promoting sustainable practices across the region. As these programs continue to evolve, they aim to not only reduce FOGs and POGS in wastewater but also enhance community involvement in environmental protection, ultimately contributing to improved ecosystems and water quality for future generations.

Objectives

- Reduce the amount of fats, oils, and greases that reach the water infrastructure.

Actions

**NEW* WM-06 Collaborate with municipalities and state agencies to establish FOGs pollution prevention initiatives across the region. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify hotspots where FOGs are the main issue in wastewater infrastructure.	Develop detailed maps with hotspots.	Identified trends and patterns of FOG and related issues.	Lead: PRASA Implementing partners: Estuario, municipalities, community action groups, commercial businesses	Pending	0-2 years	TBD	PRASA, USEPA, municipalities
2. Design and implement initiatives based on the strategic model and in close collaboration with communities.	Increase community participation in design process.	Developed draft proposals for initiatives and establish metrics to assess effectiveness.	Lead: PRASA Implementing partners: Estuario, municipalities, community action groups	Pending	3-5 years	TBD	PRASA, USEPA, municipalities

Regulatory and Policy Requirements

DNER will need to increase enforcement of regulations (Law 212-2012) related to FOGs and POGS to reduce the effects on wastewater systems. PRASA will also need to increase their regulation of FOGs and POGS for the private sector under 40 Code of Federal Regulations Part 403.

References

PRASA. 2024a. Oil and Grease Control Program. San Juan, Puerto Rico. Retrieved from BROCHURE_PROGRAMA_PARA_EL_CONTROL_DE_ACEITES_Y_GRASA_FINAL_2024.pdf.

PRASA. 2024b. Oil and Grease Control Program: Food Establishment Inspection. San Juan, Puerto Rico. Retrieved from BROCHURE_INSPECCI_N_A_ESTABLECIMIENTOS_DE_COMIDA_2024.pdf.

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Estuario. 2025a. That it does not touch the floor or reach the water. San Juan Bay Estuary Program. Retrieved from https://estuario.org/desechos-acuaticos/.

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Hazardous and Industrial Materials

Baseline

The Resource Conservation and Recovery Act was enacted in 1976. The legislation gave USEPA the authority to regulate the generation, transportation, treatment, storage, and disposal of hazardous waste, as well as to establish a framework for managing non-hazardous solid waste. Its primary goal is to protect people and the environment from the potential hazards of waste disposal; promote resource conservation, storage, and recovery; and ensure environmentally sound waste management practices. Of critical importance in this act is the protection of surface water and groundwater. The Resource Conservation and Recovery Act also regulates underground tanks storing petroleum and hazardous substances. Petroleum storge requires best management practices, inspection, maintenance, and control measures and proper response to spills. For facilities exceeding certain storage volumes and with potential to discharge petroleum to surface water, spill prevention control and countermeasures plans are required. These plans outline specific measures for each location to inspect, maintain, and ensure controls are in place for petroleum storage, and also provide spill response actions should a release occur. Annual training is required for all oil handling personnel to ensure that the plan is understood and followed.

Law No. 172 establishes the public policy regarding the collection, storage, transportation, proper handling, and final disposal of used oil generated in Puerto Rico. The purpose of the law is to prevent improper disposal of used oil and eventual environmental contamination. The law created the necessary infrastructure so that the motor oil generated by citizens is properly handled until its final disposal. The law also establishes a charge for used oil disposal by including a $0.25 per quart fee in the cost of lubricating oil or $0.60 per gallon for bulk oil. The Puerto Rico Department of Economic Development and Commerce (DEDC) manages the administration of funds, with 65% of the money collected used for the transportation and final disposal, 11% for the work of consumer education and administration and enforcement of the law, and the remaining 24% is kept in a special account for environmental emergency situations. The Law of the Promotion of the Reduction of Hazardous Waste in Puerto Rico was signed into law in 1995, and established the public policy for hazardous waste management, created a state program for technical assistance for hazardous waste management, and allocated funds for the implementation. The law establishes a hierarchy of waste management that includes:

- Reduce the production of hazardous waste.
- Reuse in industrial processes.
- Recycle at origin or other safe locations.
- Treat to reduce volume and toxicity.
- Store properly.
- Dispose safely to prevent leaks.

Other contaminants to the SJBE include metals such as aluminum, iron, lead, zinc, nickel, mercury, silver, and copper from normal corrosion of metals adjacent to waterways, industrial operations, and boat maintenance. A 2011 study identified copper and mercury in excess of the threshold effects level in nearly all sediment samples collected. Zinc, nickel, lead, and copper exceeded the probable effects level in at least one sample. More recent sediment core sampling and composite-core analyses completed by ANAMAR Environmental Consulting in 2021 reproduced elevated metal concentrations in the San Juan Bay (Bauzá-Ortega & Lugo, 2024). Metals were also measured in crab tissue and fish tissue samples, and only arsenic

exceeded the USEPA cancer and noncancer risk concentrations, and copper, selenium, silver and zinc exceeded the laboratory reporting limit, but less than the USEPA cancer and non-cancer risk concentrations (Otero, 2011).

Organic contaminants, including pesticides, herbicides, and polychlorinated biphenyls (PCBs) are also a concern. Pesticides and herbicides are typically from agricultural sources as well as commercial and residential runoff like industrial discharge, urban runoff, and historical waste disposal. PCBs are often found alongside other pollutants such as dichlorodiphenyltrichloroethane (DDT), chlordane, and mercury, suggesting combined sources. The 2011 study also looked at organic contaminants. Organic contaminants in sediment were low or not detected. PCBs in fish tissue approached or exceeded USEPA screening values for recreational fisheries; however, PCBs were not detected in crab tissue samples. Pesticides and herbicides were detected in fish and crab tissue samples, but at concentrations less than USEPA screening values. DDT levels in fish tissue were lower than in previous studies, again suggesting bans have been effective in favorable change in environmental conditions (Otero, 2011).

Objectives

- Reduce discharges of hazardous and industrial materials.

Actions

WM-07 Enforce the Used Motor Oil Management Law in the Estuary's Watershed (Law No. 172).

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Create an online database where individuals can see locations to properly dispose of used motor oil.	Update website with the map of the collection and disposal facilities in the SJBE categorized by the types of waste they handle.	Updated website annually.	Lead: Estuario Implementing partners: Municipalities, DNER	Ongoing	3-5 years	TBD	USEPA, DNER, DEDC, municipalities
2. Monitor commercial compliance of the law and evaluate whether increased enforcement and/or modifications to regulations are required.	Improve compliance with Law No. 172 and reduce the amount of illegally dumped and abandoned waste oil.	Evaluated enforcement actions and collection and disposal data and modified regulations as needed.	Lead: Municipalities Implementing partners: Estuario, DNER	Pending	3-5 years	TBD	USEPA, DNER, DEDC municipalities

Regulatory and Policy Requirements

Amendments to the present regulation should be considered.

**NEW* WM-08 Reduce Hazardous and Industrial Materials Contributions to the SJBE. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Monitor and research to better understand hazardous and industrial materials entering and within the waters and sediments of the SJBE.	Gain an understanding of contaminant types, sources, transport, pathways, loads, and wildlife burdens.	Prepared an action plan to reduce hazardous and industrial materials.	Lead: DNER Implementing partners: Estuario, U.S. Army Corps of Engineers (USACE)	Ongoing	2-5 years	TBD	USEPA, DNER, USACE, municipalities
2. Implement action plans to reduce hazardous and industrial materials and continue assessing affects.	Decrease known contaminant loads from sources and continue to better understand hazardous and industrial material contributions.	Decreased known hazardous and industrial material contributions.	Lead: DNER Implementing partners: Estuario, USACE	Ongoing	3-6 years	TBD	USEPA, DNER, USACE, municipalities

Regulatory and Policy Requirements

Additional regulations may be needed to manage hazardous and industrial materials based on the results of this action.

References

Bauzá-Ortega, Jorge and Lugo, Ariel. 2024. San Juan Bay Estuary: Research History and Opportunities.

Otero, E., & Meléndez, A. 2011. Estuarine Environmental Indicators for the San Juan Bay Estuary: Assessment of Sediment and Fish Tissue Contaminants. San Juan Bay Estuary Program & United States Environmental Protection Agency, Region 2.

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Ports and Vessels

Baseline

The waters of the SJBE are widely used for boating activities of all kinds. While continued use of the estuary's waters for boating activities is necessary and important for the economy of the local area and indeed the entire island, it is also vital to minimize adverse effects to the SJBE system associated with these activities. The SJBE is the center of commerce and tourism for the state of Puerto Rico. Each year, 80% of the products that Puerto Rico imports arrive through the ports and airports located in the SJBE area. The San Juan pier received 1.8 million tourists through 558 cruises based on the island or in transit, as per the official data of the 2018–2019 fiscal year. During that same time period, 4.5 million travelers came through the Luis Muñoz Marín International Airport, and the Fernando Ribas Dominicci airport in Isla Grande welcomed 19,616 passengers. The SJBE has been altered to accommodate these cargo and travelers. This section provides the actions and activities to reduce debris and other materials and pollutants generated from ports and vessels.

The International Convention for the Prevention of Pollution from Ships (MARPOL) since 1973 has covered pollutant prevention from ships due to operations or accidental releases. The convention and subsequent annexes include a requirement for new oil tankers to be double hulled after 1992, discharge criteria for noxious substances (including a ban of any discharge within 12 miles of land), labeling requirements for harmful substances, sewage and garbage discharge controls, and a ban on discharges of plastics. Bilge water is another common pollutant from small vessels and ships, and may contain fuel, oil, grease, and other residues. Bilge water should be collected for disposal or treated per MARPOL prior to discharge.

The use of watercraft in shallow waters is of particular concern due to sediment and contaminant resuspension, which increase resultant turbidity, increase turbulence, lacerate aquatic vegetation with loss of faunal habitat and substrate stability, emit chemicals from boat engines, and affect aquatic organisms. Developing special use areas designated for specific maritime functions help to balance economic interests with environmental protection. These areas include zones for commercial shipping and industrial activities, recreational boating and paddling, and tourism-related zones for cruise ships. The designation of special use areas will need to be a collaboration between stakeholders and relevant community members to mitigate conflicts between different types of watercrafts and to preserve the estuary's ecological function.

Marinas, fishing villages, and yacht clubs provide crucial services to small boats, including maintenance, dockage and storage, and refueling. However, their location near waterbodies and the nature of their operations generate pollution in the estuary's waters. The two primary sources of pollution are sewage and spills of fuels, lubricants, detergents, and debris associated with boat maintenance activities, particularly from bilge water. These pollutants affect marine populations and endanger many species economically important to the residents and biological communities, including reducing dissolved oxygen and adding heavy metals and toxic chemicals. In addition, the construction of the infrastructure for this type of operation negatively affects the benthic populations of these natural systems.

The construction of marinas and port facilities, along with the dredging of navigational channels, leads to the direct destruction of natural shallow water habitats. Moreover, the shipping industry and yachting activities associated with marinas and ports may result in the contamination of sediments and the water column inside and in the vicinity of the piers, which can have long-term consequences on living organisms (Bauzá-Ortega 2016). Coordinating cleanup efforts with local marinas, boaters, and volunteers will be essential for developing better boating practices and reducing the number of spills.

Many boaters are careful about their boat operation and maintenance of their boats. However, those that do not show the same respect can have significant effects on the SJBE system. Discharges from marine sanitation devices, pollutants from spilled fuel, detergents from boat cleaning, and pollutants from paints can affect water quality. Boat traffic generates wakes that erode shorelines and affect aquatic organisms, traveling through offshore shallow areas and digging up the bottom sediments, and scarring seagrass and other vegetation. Boating can also lead to littering, which can affect aquatic organisms. The federal Marine Pollution Prevention Act prohibits sanitary waste discharges within 2 miles of shore; however, for inshore boaters and transients, main pump out facilities are required at marinas to facilitate compliance. Programs to promote the installation of pump out facilities and best management practices for boat yards and boaters would improve water quality in the SJBE. The Florida Clean Marina and Clean and Resilient Marina programs and the Massachusetts Coastal Zone Management Office are examples of such programs. Boater education on the effects of sanitary discharges, use of marine sanitary devices, accessibility to sanitary pump out facilities, and best boating practices are key to protecting the SJBE system.

Objectives

- Reduce the amount of waste and litter generated at ports and vessels.

Actions

WM-09 Assess the establishment of non-commercial watercraft special use areas in the SJBE.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Adopt and implement regulations concerning appropriate areas for the use of non-commercial watercraft within the SJBE system.	Use of and amount of watercraft in appropriate locations of the system to protect natural resources.	Implemented and adopted regulations.	Lead: DNER Implementing partners: U.S. Fish and Wildlife Service (USFWS), municipalities	Pending	0-2 years	TBD	DNER
2. Develop a comprehensive inventory of existing docks and watercraft facilities within the SJBE system, including compliance status.	Improved information on location and compliance status of facilities.	Developed an inventory.	Lead: DNER Implementing partners: USCG, municipalities, private marinas	Pending	0-2 years	TBD	DNER, USFWS
3. Create a reporting system to document findings and recommend corrective actions or enforcement measures for non-compliant facilities.	Better compliance with proposed regulations for the use of watercraft within the SJBE system.	Prepared annual reports.	Lead: DNER Implementing partners: USFWS, municipalities	Pending	3-5 years	TBD	DNER, USFWS, USEPA

Regulatory and Policy Requirements

To be determined based on the identified regulations.

WM-10 Develop a project to reduce and prevent pollution in marinas, fishing villages, and yacht clubs in the SJBE. ADAPTATION

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Continue distributing a Clean Marinas Handbook detailing actions that can be taken by users and managers of marinas and yacht clubs to reduce levels of aquatic pollution.	Identify a trend in pollutant reductions from marinas and yacht clubs.	Handbook distributed.	Leads: USFWS, DNER Implementing partners: Puerto Rico Tourism Company, marinas and yacht clubs, USCG	Pending	0-2 years	TBD	DNER, USFWS, USEPA
2. Add monitoring stations for bacteria, oils, lubricants, and other pollutants at the SJBE's main marinas and yacht clubs.	Improve information about sources of pollutants from marinas and yacht clubs.	Monitoring initiated, and reports completed annually.	Leads: DNER, USFWS Implementing partners: Marinas and yacht clubs, USCG	Pending	0-2 years	TBD	DNER, USFWS, USEPA
3. Install pump and clean out stations in marinas and yacht clubs.	Reduce pollutants from marinas and yacht clubs.	Pump and clean out stations installed.	Lead: DNER Implementing partners: Marinas and yacht clubs, USCG	Pending	3-5 years	TBD	USEPA
4. Provide educational materials and programs for boat owners and operators to reduce sanitary waste and spills from boat maintenance, refueling, and bilgewater.	Guidance for boaters to follow to protect the SJBE system.	Developed a curriculum with stakeholders that covers best practices specifically for boat owners and operators.	Leads: DNER, USFWS Implementing partners: Municipalities, marinas and yacht clubs, boating organizations, USCG	Pending	0-2 years	TBD	DNER, USFWS
5. Identify and remove abandoned vessels from the SJBE system.	Remove abandoned vessels to reduce the potential for contamination from these vessels.	Removed all abandoned vessels from the SJBE system.	Lead: DNER Implementing partners: USCG, NOAA, USACE	Pending	5+ years	TBD	DNER, USCG, NOAA

Regulatory and Policy Requirements

Sewage discharges from watercraft are considered a violation of the clean water standards established by DNER for surface waters and aquatic systems in Puerto Rico. It will be necessary to establish and implement a compliance program.

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Emerging Contaminants of Concern

Baseline

The term "contaminant of emerging concern" is used by USEPA and other agencies to identify chemicals and other substances that have no regulatory standard, have been recently identified in natural waterways (often because of improved analytical chemistry detection levels), and potentially cause harmful effects in aquatic life at environmentally relevant concentrations. They are pollutants not currently included in routine monitoring programs and may be candidates for future regulation depending on their toxicity, potential effects, public perception, and frequency of occurrence in environmental media. Contaminants of emerging concern are not necessarily new chemicals. They include pollutants that have often been present in the environment but whose presence and significance are only now being evaluated (USEPA, 2008).

One example is per- and polyfluoroalkyl substances (PFAS), which are synthetic chemicals that have been used in fire-fighting foam and other industrial and household products for more than 50 years. They have been identified in marine wildlife and fish tissue. These chemicals have been shown to cause liver, immune, and developmental toxicity in animals. They bioaccumulate and biomagnify, are persistent in the environment, and have been shown to have negative effects at very low doses.

Microplastics are another contaminant of emerging concern in the SJBE. Generally, between 5 millimeters and 1 nanometer in size, microplastics are small plastic particles derived from the breakdown of larger plastic marine debris (USEPA, 2025). Another source is from the direct manufacture of microfibers used in synthetic clothing and microbeads, such as those found in cleansers and cosmetics. The Microbead-Free Waters Act of 2015 banned the manufacturing and delivery of rinse-off cosmetics with microbeads, so this source of microplastics will be reduced over time (U.S. Food and Drug Administration, 2025). Sand from six northern beaches of Puerto Rico was collected in the high tide line to determine microplastic abundance. Península La Esperanza, the most polluted beach, exhibited higher average abundance of 17 items per kilogram of dry weight and diversity of materials. High urbanization, industrial/port activities, and riverine input are likely sources of plastic debris on this beach (Pérez-Alvelo et. al, 2021). The properties of plastics also allow for adsorption of persistent organic pollutants, and concentration of toxins and heavy metals. These plastics also include biofilms, which can carry harmful algal bloom species and pathogenic microbes. (Avio, 2016; Keswani, 2016; Kowalski, 2016; Vermeiren, 2016; Wang, 2016). Estuario has developed a workshop to educate citizen scientists on the importance of microplastics and sampling means and methods for microplastics monitoring (Estuario, 2025).

Objectives

- Determine how emerging contaminants of concern impact ecosystem and public health.

Actions

**NEW* WM-11 Reduce emerging contaminants of concern loads to the SJBE.* *Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Monitor and research to better understand emerging contaminants of concern entering and within the waters and sediments of the SJBE.	Increase knowledge about contaminant types, sources, transport, pathways, loads, and wildlife burdens.	Prepared an action plan to reduce emerging contaminants concern loads.	Lead: DNER Implementing partners: Estuario, USACE	Ongoing	2-5 years	TBD	USEPA, DNER, USACE, municipalities
2. Implement action plans to reduce emerging contaminants of concern loads and continue assessing effects.	Decrease known contaminant loads from sources and continue to better understand emerging contaminants.	Decreased known emerging contaminants of concern loads.	Lead: DNER Implementing partners: Estuario, USACE	Ongoing	3-5 years	TBD	USEPA, DNER, USACE, municipalities

Regulatory and Policy Requirements

Additional regulations may be needed to manage emerging contaminants of concern based on the results of this action.

**NEW* WM-12 Assess the magnitude of the microplastics issue in the SJBE and implement measures to manage it effectively.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Characterize microplastics and assess the magnitude of the issue in the SJBE system.	Increase in the number of citizen scientist certificates issued in the SJBE.	Gathered monitoring and research.	Lead: Estuario Implementing partners: Municipalities, Puerto Rico Ports Authority (PRPA), DNER	Pending	3-5 years	TBD	USEPA, DNER
2. Inform and generate awareness to address microplastics and implement improvements.	Increase awareness of microplastics and how to reduce microplastics in the system using Estuario's Citizen Science Certification.	Reduced microplastics concentration in the SJBE system.	Lead: Estuario Implementing partners: Municipalities, PRPA, DNERA, port facilities, local organizations	Pending	5+ years	TBD	USEPA, DNER

Regulatory and Policy Requirements

Modifications to regulations, including Law 51-2022 and Law 247-2015, will be determined based on the outcomes of this action.

References

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Vegetative Materials and Sediments

Baseline

The SJBE is increasingly challenged by the management of vegetative materials and sediments. Historically, the improper disposal of organic waste has contributed to environmental degradation and sedimentation issues within the estuarine ecosystem. About 30% percent of waste in Puerto Rico is characterized as organic waste, such as food scraps and yard waste, all of which can bypass the landfill (DNER, 2024). In response to these challenges, various municipalities, notably Bayamón, Carolina, and Caguas, have initiated significant efforts to improve the management of organic materials. These efforts are crucial not only for protecting the estuary but also for aligning with public policies that govern waste management practices.

The municipalities of Caguas, Carolina, and Bayamón have established collaborative programs for organic material collection aimed at processing the material into valuable resources such as compost, biofertilizers, and biogas. This approach is part of a wider strategy to enhance local food security in Puerto Rico through the diversion and processing of organic waste, thereby reducing the volume of refuse entering landfills (Estuario, 2022). In Bayamón, El Centro de Preservación Ecológica in the barrio Guaraguao (active since 2012) receives municipal collections and public drop-offs of vegetative and woody wastes and processes them into market-ready compost through a managed curing regimen (City of Bayamón, 2025). The municipalities are under regulatory obligations to collect organic materials and ensure their transportation to composting facilities. These mandates are further supported by the provision of resources and financial incentives that facilitate the implementation of sustainable waste management practices across municipalities.

Recognizing the urgent need for systemic reform, a progressive plan has been developed to incorporate domestic collections of organic waste types 1 and 2. Organic waste type 1 includes vegetative materials such as leaves, branches, and non-toxic woods, while organic waste type 2 encompasses food waste consisting of discarded food items and paper or cardboard contaminated with food residues (Circular Generation, 2021). This initiative is set to commence with municipalities that exhibit higher populations, with the ultimate goal of ensuring comprehensive domestic organic waste collection across all jurisdictions by 2028 (Estuario, 2022). Such proactive measures represent a significant step toward environmentally sustainable practices and aim to minimize the amount of organic waste sent to landfills.

In addition to these collection efforts, regulations surrounding organic waste deposition are undergoing substantial changes. Explicitly, a strategy to regulate the deposition of organic materials into landfills was passed with the intent to legally prohibit such practices by 2028 (Circular Generation, 2021). As part of this regulatory framework, there are plans to amend Article 7 of Law 70-1992, which will classify organic waste types 1 and 2 as recyclable materials that require separation and classification at the source. Consequently, municipalities will be mandated to collect and transport these organic materials to appropriate composting facilities (Environmental Quality Board, 2016). Other key regulations related to the management of vegetative material include Regulation 8881 (Regulation for the Design and Operation of Composting Facilities) and Regulation 9306 (Regulation for Sanitary Landfill Systems).

To enforce compliance with the regulations, the establishment of a government enforcement unit has been proposed. This unit will oversee the proper disposal practices among participating municipalities and impose penalties for violations of organic waste deposition policies (Circular Generation, 2021). Such stringent measures highlight the commitment to reducing organic waste in landfills and emphasize the

importance of diverting these materials into productive uses, benefiting both the community and the ecosystem.

Moreover, initiatives to integrate municipal sawmills into the waste management strategy signify a multifaceted approach toward resource utilization. By collaborating with municipalities to collect and process wood, makeshift solutions arise where usable wood can be distributed as raw material while unusable wood is directed to composting facilities. This strategy not only optimizes the use of vegetative resources but also aids in reducing the volume of waste that would otherwise contribute to the pollution of the estuary (Estuario, 2022).

The ongoing efforts among municipalities to improve the management of vegetative materials and sediments underscore a coordinated approach to addressing waste and sedimentation issues in the SJBE. Through collaborative initiatives, regulatory reforms, and community engagement, stakeholders are laying the foundation for a more sustainable future. This groundwork will facilitate actionable activities aimed at enhancing the system's ecology, ensuring the preservation of this vital resource for future generations.

Objectives

- Reduce the amount of vegetative materials and sediments that are disposed of in landfills.

Actions

**NEW* WM-13 Implement a collection system of vegetative materials across the region. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess current regulations and policies, and how to better enforce those regulations and policies.	Evaluate current compliance levels.	Improved level of compliance with current regulations and policies.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	0-2 years	TBD	DNER, municipalities
2. Ensure enhanced collection during high-volume times, such as after an extreme event or during the holiday season.	Assess operational capacity of collection services during peak periods.	Determined the effectiveness of enhanced collection efforts.	Leads: Department of Transportation and Public Works (DTOPW), municipalities Implementing partners: DNER, LUMA, Estuario	Pending	3-5 years	TBD	DNER, municipalities
3. Support efforts for an estuary-wide vegetative materials collection project similar to the ones in Bayamón, Carolina, and other municipalities.	Improve proper disposal of vegetative materials.	Assessed current practices and available resources for an estuary-wide effort.	Leads: DTOPW, municipalities Implementing partner: Estuario	Pending	3-5 years	TBD	DNER, USDA, municipalities

Regulatory and Policy Requirements

A review of current regulatory requirements will be necessary to improve implementation of the Regulations for Landfill Systems, Regulations for the Design and Operation of Composting Facilities, and Law No. 15 to Promote Vegetable Recycling and Composting in Puerto Rico Schools.

**NEW* WM-14 Improve and expand the current infrastructure to support the correct management of vegetative materials.* *Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify needs for expanding current infrastructure.	Conduct assessment to identify gaps based on current usage and future demand.	Prepared an Inventory of existing assets and potential or known limitations.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	0-2 years	TBD	DNER, USDA, municipalities
2. Design and implement solutions based on strategic modeling and ensure close collaboration with communities.	Improve infrastructure and amount of vegetative materials entering landfills.	Organized workshops with community members throughout the process.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	3-5 years	TBD	DNER, USDA, municipalities

Regulatory and Policy Requirements

A review of current regulatory requirements will be necessary to see how implementation can be improved.

**NEW* WM-15 Promote the composting industry to close the loop on a circular waste management system.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify opportunities for improvement within the current system.	Conduct assessment to identify gaps based on current usage and future demand.	Inventoried existing assets and potential or known limitations.	Lead: DNER Implementing partners: Estuario, municipalities, composting organizations	Pending	0-2 years	TBD	DNER, USDA, municipalities
2. Design and implement solutions based on strategic modeling and ensure close collaboration with communities.	Improve the composting infrastructure.	Organized workshops with community members.	Lead: DNER Implementing partners: Estuario, municipalities, composting organizations	Pending	3-5 years	TBD	DNER, USDA, municipalities

Regulatory and Policy Requirements

A review of current regulatory language and policies on composting will need to be conducted.

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Air Contaminants

Baseline

The SJBE is a vital ecological and economic resource. However, this system is increasingly threatened by air contaminants stemming from multiple anthropogenic sources. Establishing a comprehensive baseline of air quality conditions is essential for effective management for the environmental and local communities.

Urbanization in the SJBE watershed has intensified over recent decades, leading to increased emissions of air pollutants from vehicular traffic, industrial operations, power generation, and residential activities. According to the U.S. Forest Service's SJBE Watershed Urban Forest Inventory, the watershed's urban forest plays a mitigating role in air pollution by filtering particulate matter and absorbing gaseous pollutants. However, this natural benefit is often overwhelmed by high pollutant loads, including fine particulate matter, nitrogen oxide, sulfur dioxide, carbon monoxide, volatile organic compounds, and ground-level ozone precursors (Brandeis et al., 2014).

Scientific investigations by USEPA have documented the presence of various contaminants of emerging concern within the SJBE, reflecting the complex interplay between air and water pollution pathways. These contaminants include persistent organic pollutants and heavy metals that can be transported atmospherically and deposited into the estuarine waters, affecting aquatic life and water quality. Enhanced air pollution monitoring efforts supported by USEPA's Office of Research and Development (ORD) have focused on identifying pollution hotspots and characterizing temporal trends in communities near the estuary (USEPA ORD, 2021).

In 2022, USEPA announced targeted initiatives to protect communities around the SJBE by addressing key pollution sources, including air emissions from industrial facilities and traffic corridors. These actions aim to reduce exposure to harmful pollutants and improve overall air quality through regulatory enforcement and community engagement programs (USEPA, 2022).

DNER maintains an Air Quality Index system that continuously monitors concentrations of critical pollutants such as ozone, particulate matter, nitrogen oxide, sulfur dioxide, and carbon monoxide at multiple stations across the island, including those near the SJBE. Data from DNER indicate that while general air quality trends show some improvement, episodic exceedances of air quality standards remain a concern. Ozone and particulate matter levels frequently approach or surpass thresholds, driven by local emissions and regional atmospheric transport influenced by meteorological conditions such as temperature inversions and sea breezes (DNER, 2024).

The implications of these air contaminants are significant for residents of the San Juan metropolitan area, contributing to increased rates of respiratory illnesses, cardiovascular diseases, and other chronic conditions. Additionally, the estuarine ecosystem is susceptible to the effects of atmospheric deposition of nitrogen compounds and heavy metals, which can lead to eutrophication, harmful algal blooms, and degradation of habitats critical for fish and bird species. Methane and other greenhouse gases also emanate from organic matter decomposition, adding to the regional greenhouse gas burden.

The baseline air quality conditions in the SJBE reflect a complex mixture of urban and industrial pollutants that pose ongoing challenges to the environment and local communities. The integration of continuous monitoring data, scientific research, and regulatory initiatives provides a foundation for developing adaptive

management strategies aimed at reducing air pollution sources, protecting local communities, and preserving the ecological integrity and water quality of this important coastal estuary.

Objectives

- Reduce the impact to water quality in the estuarine system due to atmospheric deposition of air contaminants.

Actions

**NEW* WM-16 Assess the effect of atmospheric deposition of air contaminants on the SJBE and implement recommendations to address the issue.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify and apply for funding to evaluate air contaminant impacts on the SJBE.	Obtain funding to evaluate air contaminant impacts on the SJBE.	Applied for and obtained funding for air contaminant evaluations.	Lead: DNER Implementing partners: Estuario, municipalities, local environmental groups	Pending	0-2 years	TBD	USEPA, NOAA, National Weather Service
2. Upon obtaining funding, identify current air contaminant hotspots and effects on water quality, and assess solutions to improve current conditions.	Identify current air contaminant effects and hotspot areas for improvement.	Gathered feedback and information on current conditions.	Lead: DNER Implementing partners: Estuario, municipalities, local environmental groups	Pending	3-5 years	TBD	DNER, USEPA, municipalities, National Weather Service, University of Puerto Rico Medical Sciences Campus
3. Define and implement solutions to address air contaminants in close collaboration with communities.	Reduce the concentration of measured air contaminants and improve water quality.	Organized workshops with community members to identify solutions.	Lead: DNER Implementing partners: Estuario, municipalities, local environmental groups	Pending	5+ years	TBD	DNER, USEPA, municipalities, National Weather Service, University of Puerto Rico Medical Sciences Campus

Regulatory and Policy Requirements

Regulatory modifications may be required based on the outcomes of this action to improve enforcement of the federal Clean Air Act and Puerto Rico Air Pollution Control Regulations.

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Public Policy for Integrated and Sustainable Materials and Waste Management

Baseline

The SJBE watershed is a densely populated and economically active region of Puerto Rico that generates nearly one-third of the island's solid waste despite covering less than 8% of its land area. This disproportionate waste generation presents considerable logistical, environmental, and economic challenges for the municipalities within the estuary's watershed. Solid waste management in this region has historically relied on collection and disposal in landfills or sanitary landfills, many of which face capacity limitations, compliance issues, and environmental risks. As of 2021, 11 of the 29 final disposal facilities in Puerto Rico had closure orders issued by USEPA, highlighting the ongoing challenges in maintaining environmentally sound waste management infrastructure. These difficulties were further intensified by natural disasters such as Hurricanes Irma and María in 2017, which increased the volume of debris, vegetative materials, and construction waste, putting additional strain on already limited disposal capacities (Circular Generation, 2021).

Efforts to manage waste effectively are complicated by fragmentation and limited coordination among municipalities, private companies, community organizations, and other stakeholders. While some municipalities have companies engaged in waste processing, composting, and recycling, these activities are often isolated and lack integration into a comprehensive circular economy framework. This fragmentation restricts the potential for scaling up reuse, recovery, and recycling efforts, which are essential for reducing landfill dependence and minimizing environmental effects. Estuario has underscored the importance of improving the quality of the estuarine habitat and enhancing its recreational, aesthetic, and economic values by maintaining a watershed with significant aquatic waste reduction. Achieving this objective demands systemic coordination beyond municipal boundaries to maximize the efficient use of resources and the sustainable management of waste.

Puerto Rico's legislative framework provides a foundation for integrated waste management through laws such as the Solid Waste Reduction and Recycling Act of 1992 and the federal Resource Conservation and Recovery Act; the Puerto Rico statute explicitly established a hierarchy of management and directs DNER to develop a Solid Waste Reduction and Recycling Program, which promotes waste reduction, source separation, recycling, and responsible disposal of non-hazardous solid waste (Law 70-1992). Additional environmental statutes and the Constitution of Puerto Rico support the principles of sustainable resource management and ecosystem conservation. Despite this legal infrastructure, enforcement challenges and limited municipal capacity have hindered the full realization of these policies at the local level, resulting in inconsistent implementation and gaps in waste diversion and reuse of materials.

A growing consensus advocates for the adoption of a circular economy model that recognizes waste as a resource, emphasizing reduction at the source, sustainable production and consumption, and maximizing local economic development and innovation. This approach also highlights shared responsibility among citizens, communities, governmental agencies, and the private sector to foster environmental stewardship and social equity. Public policies aligned with circular economy principles reject environmentally harmful practices such as incineration and instead promote alternatives like composting, material recovery, and extended producer responsibility. While there are companies and initiatives in San Juan and neighboring municipalities involved in composting, electronic waste collection, and recycling, municipal collaboration remains limited. This lack of coordinated engagement extends to public campaigns, which have been

sporadic or absent, particularly for materials like electronic waste and batteries, representing a missed opportunity to increase diversion rates and reduce environmental burdens.

Integrated and sustainable materials and waste management in the SJBE requires reinforcing intermunicipal coordination, enhancing municipal and community capacity, ensuring effective enforcement of existing laws, and embedding circular economy principles into policy and practice. By overcoming current fragmentation and limitations, the region can move toward a more sustainable and equitable waste management system that benefits the environment and fosters economic opportunities.

Objectives

- Strengthen public policy that supports integrated and sustainable materials and waste management.

Actions

**NEW* WM-17 Continue strengthening the Intermunicipal Network for Integrated Resources and Materials. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Support integrated resources and material management practices through the existing memorandum of agreement.	Support collaboration through the existing memorandum of agreement.	Organized initial meetings with stakeholders.	Lead: Estuario Implementing partners: municipalities, DMER	Pending	3-5 years	TBD	USEPA
2. Hold annual meetings where members can present and discuss opportunities and collaboration to improve integrated management.	Increase in member participation.	Improved collaboration and engagement from network members.	Lead: Estuario Implementing partners: municipalities, DNER	Pending	3-5 years	TBD	USEPA
3. Identify and initiate collaborative projects among member municipalities.	Increase in amount of projects that move from planning to implementation.	Identify potential funding sources for projects.	Lead: Estuario Implementing partners: municipalities, DNER	Pending	5+ years	TBD	DNER, municipalities

Regulatory and Policy Requirements

Improvements to the regulation and enforcement of the Municipal Code of Puerto Rico (Law No. 107 of August 14, 2020) Chapter VI: Recycling and Solid Waste Management will be required.

**NEW* WM-18 Create an integrated information system for materials and waste management that provides data uniformity across jurisdictions to facilitate reporting and ensure compliance with existing public policy.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Assess what data and information are collected across jurisdictions and how it is gathered to identify opportunities.	Inventory existing data and identify any data gaps.	Determined data quality and areas for opportunities.	Leads: DNER, Puerto Rico Innovation and Technology Service (PRITS) Implementing partners: Estuario, Puerto Rico Science, Technology & Research Trust (PRTRUST), Intermunicipal Network, Institute of Statistics	Pending	0-2 years	TBD	USEPA, DNER, municipalities
2. Design and implement an integrated information system.	Identify stakeholder needs for an information system.	Evaluated system performance and assess if it meets determined goals.	Lead: DNER Implementing partners: Estuario, Intermunicipal Network, PRITS, Institute of Statistics	Pending	3-5 years	TBD	USEPA, DNER, municipalities

Regulatory and Policy Requirements

None.

**NEW* WM-19 Ensure municipalities have the necessary infrastructure and equipment to support effective integrated management. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess needs, prioritize infrastructure, and identify funding sources.	Complete a needs assessment.	Identified gaps in current practices, resources, and/or infrastructure.	Leads: DNER, municipalities Implementing partners: Estuario, Intermunicipal Network	Pending	0-2 years	TBD	DNER, municipalities
2. Design, build, and maintain infrastructure.	Develop detailed plans for infrastructure.	Monitored construction activities and ensure work is on schedule.	Leads: DNER, private sector Implementing partners: Estuario, Intermunicipal Network	Pending	3-5 years	TBD	DNER, municipalities, USEPA, USDA, private sector

Regulatory and Policy Requirements

Improvements to the regulation and enforcement of Law 23-1972, Law 70-92, and the Municipal Code will be required.

**NEW* WM-20 Develop and implement an educational program regarding integrated materials management. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify target audiences and specific educational needs, including messages for children, to promote better waste management.	Identify challenges that can be addressed through educational programs.	Determined community educational needs regarding integrated materials management.	Lead: Estuario Implementing partners: municipalities, DNER	Pending	0-2 years	TBD	USEPA, DNER
2. Develop and distribute educational materials in way that is engaging and accessible to the public.	Engage with stakeholders to create materials and programming.	Reviewed materials for accessibility and developed a distribution strategy.	Lead: Estuario Implementing partners: municipalities, DNER	Pending	0-2 years	TBD	USEPA, DNER
3. Launch educational programming and gather feedback to improve accessibility and outreach.	Collect feedback from participants and stakeholders on programming.	Increased community knowledge on integrated materials management.	Lead: Estuario Implementing partners: municipalities, DNER	Pending	3-5 years	TBD	USEPA, DNER
4. Prohibit single-use plastics within the SJBE watershed.	Implement programs to prohibit single-use plastic.	Reduced the amount of single-use plastic.	Lead: DNER, Department of Consumer Affairs Implementing partners: Estuario, municipalities, private waste management and recycling companies, community groups	Pending	5+	TBD	DNER, municipalities

Regulatory and Policy Requirements

This program will help with implementation of Law 51-2022.

References

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