# STORMWATER REPORT CARD FOR MIAMI-DADE COUNTY:

## MS4 permit compliance for Miami-Dade County and its municipalities from 2021 to 2023

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# 1. Executive Summary

Biscayne Bay is one of Miami-Dade County's most vital natural and economic resources, but it is under growing stress from pollution, urbanization, and climate change. Stormwater runoff, which carries nutrients, sediments, and other pollutants into the Bay, is a leading cause of its decline. Effective stormwater management is therefore central to protecting water quality, reducing flooding, and ensuring long-term community resilience.

Building on the findings of the 2022 Stormwater Compliance Report, this report re-evaluates the performance of 34 Municipal Separate Storm Sewer System (MS4) permittees in Miami-Dade County, including the County, its 32 co-permittees, and the Cities of Miami and Hialeah, during permit Years 4–6 (2021–2023).[1] Using quantitative and qualitative rubrics, six independent reviewers assessed municipal compliance with key MS4 requirements.

When evaluated on quantitative compliance, Miami-Dade County and its 32 co-permittees averaged 76.5% (C), while the City of Miami scored 91% (A-) and the City of Hialeah scored 81% (B-). Qualitative compliance scores followed a similar pattern, with the County and co-permittees averaging 73.8% (C), the City of Miami earning a 96% (A), and the City of Hialeah scoring 72% (C-).

## Key Findings

- **Overall Progress:** Average municipal compliance improved from 68.7% in 2020 to 75.1% in 2021–2023, showing that all municipalities, on average, improved their compliance scores by a meaningful margin following 2020.
- **Uneven Compliance Landscape:** Although overall compliance improved, 24% of municipalities remain in the Low or Poor categories, demonstrating that progress is not evenly distributed across Miami-Dade County.
- **Planning and Documentation**: Municipalities made significant strides in updating Stormwater Management Programs (SWMPs). SWMP compliance increased from 54.5% of municipalities submitting their SWMP in 2020 to 77.1% from 2021 to 2023. Outfall mapping increased from 57.1% of municipalities in 2020 to 88.6% in 2023, a 31.5-percentage-point increase.
- **Persistent Gaps:** Despite progress in mapping and documentation, routine operational compliance, particularly inspections of pipes, culverts, catch basins, pollution control structures, outfalls, and stormwater pumps, has not demonstrated sustained

[1] We analyzed the City of Miami and City of Hialeah Permit Years 5-7 (2021-2023).

improvement and, in several categories, has declined relative to the 2020 baseline. Municipalities regularly inspecting pumps declined from 94.1% in 2020 to 78.9% in 2023, municipalities inspecting pollution control boxes went down over 10 percentage points, and municipalities inspecting outfalls only increased 2% from 2020 to 2023, to mention some examples.

- **Limited Monitoring:** Only 15% of the municipalities conduct independent monitoring, limiting local capacity to detect pollution trends.
- **Training and Education:** Staff training and public outreach programs improved modestly, though their depth and accessibility vary widely across municipalities.
- **Funding Matters:** Municipalities with larger stormwater budgets consistently achieved higher compliance, highlighting a link between investment and performance.
- **Equity and Vulnerability:** Certain social vulnerability factors correlate with lower municipal compliance, highlighting the need to address these challenges thoughtfully.
- **Outreach Works:** Municipalities that received targeted outreach following the Stormwater Report published in 2022 improved their compliance scores by an average of 10.6 percentage points vs. 3.9 points for others, demonstrating the impact of engagement and technical support.
- **Geographic Disparities:** Compliance performance is geographically clustered, with larger coastal municipalities generally achieving higher scores than smaller inland jurisdictions.
- **Regional Implications:** Because stormwater systems are hydrologically connected, uneven compliance across municipalities may pose challenges for achieving countywide watershed and Biscayne Bay water quality goals.

## Recommendations

To sustain progress and close remaining gaps, at a high level, the report recommends:

- Ensuring regular review, updates, and compliance of the municipalities' Stormwater Management Programs.
- Regular updates to stormwater infrastructure maps - including digitiziation
- Strengthening inspection and maintenance programs with standardized schedules and digital tracking.
- Expanding proactive illicit discharge detection and reporting.
- Enhancing public education with multilingual, community-based programs.
- Linking stormwater funding and grants to measurable compliance outcomes.
- The County and the State should provide training and technical assistance to under-resourced municipalities.

- FDEP needs to ensure the timely renewal of permit cycles to ensure updated conditions.
- FDEP must conduct periodic compliance audits and require corrective action plans with enforceable timelines for municipalities failing to meet inspection requirements.

Achieving full compliance from all municipalities requires them to implement consistent documentation practices, strong Stormwater Management Programs, comprehensive digital infrastructure mapping, and higher levels of compliance across required inspection and outreach categories. Municipalities would need to ensure that all required inspections are completed at the frequency specified in their MS4 permits, including routine inspections of pumps, pollution control structures, and outfalls, and continue improving proactive illicit discharge detection and public engagement efforts. Strong performance year after year would ensure that high standards translate into long-term protection of Biscayne Bay and resilience against increasing stormwater pressures.

# 2. Introduction

Biscayne Bay is one of Miami-Dade County's most valuable natural and economic assets, yet it faces increasing pressures from urbanization, pollution, and a changing climate. Among the most pressing challenges is urban stormwater runoff, a leading source of water pollution. As rain flows across paved surfaces and through aging infrastructure, it carries pollutants, including excessive nutrients, sediments, and pathogens, directly into waterways. These discharges, if left unmanaged, degrade water quality, damage seagrass and other marine habitats, increase flooding, and pose heightened risks to the environment and public health.

This report evaluates stormwater management compliance across Miami-Dade municipalities, with a focus on Municipal Separate Storm Sewer System (MS4) permits issued under the Clean Water Act. MS4 permits regulate how cities and counties manage stormwater that flows through their public drainage systems, such as storm drains, pipes, canals, outfalls, and retention basins, to ensure that pollutants are controlled before runoff reaches local waterways like Biscayne Bay. These permits require municipalities to implement a series of stormwater management practices covering public education, inspections, construction oversight, and pollution prevention.

Using a multi-year evaluation process with both 1) quantitative and 2) qualitative rubrics, the analysis identifies both strengths and persistent compliance gaps. Six independent reviewers evaluated each municipality's performance by examining submitted annual reports, stormwater management plans, and supporting documentation. The quantitative rubric measured compliance with specific permit requirements, such as inspection frequency or report submission, while the qualitative rubric assessed the quality and thoroughness of those efforts. This report builds on Miami Waterkeeper and Everglades Law Center's July 2022 report, an audit of Miami-Dade County stormwater permit compliance,[2] and updates the analysis in that report with additional years of data to track trends and progress since the original assessment.

In addition to presenting the results of a multi-year analysis of municipal compliance, this report highlights correlations among compliance, municipal budgets, outreach activities, and social vulnerability indicators. These findings inform a set of evidence-based recommendations to help local governments strengthen compliance, build municipal capacity, and ensure that stormwater management contributes to a healthier Biscayne Bay and more resilient communities.

[2] Everglades Law Center and Miami Waterkeeper, (2022). Miami-Dade County Stormwater Permit (MS4) Compliance Audit.

# 3. Relevance of Stormwater to Biscayne Bay

Biscayne Bay is a vital natural habitat at the heart of Miami-Dade County's environmental and economic identity. Stretching along the southeast coast of Florida, the Bay supports a unique mosaic of ecosystems, including seagrass meadows, mangrove forests, and coral reefs, that provide critical habitat, protect coastal infrastructure, and offer recreation and economic opportunity to millions of residents and visitors.

According to an economic valuation study, Biscayne Bay contributes an estimated $64 billion annually to the Miami-Dade County economy.[3] This economic impact stems from a wide range of uses, including:

- Boating, swimming, and sailing,
- Commercial and recreational fisheries,
- Shipping and cruise operations,
- Real estate value, and
- Tourism and waterfront culture.

Biscayne Bay is home to an extraordinary diversity of marine life, over 200 commercially and recreationally valuable fish species, and more than 30 endangered, threatened, or species of special concern, including sea turtles and manatees.[4] Biscayne Bay also has seagrass beds that stabilize sediments, filter pollutants, and provide nursery habitat; mangrove forests that

[3] South Florida Water Management District, & Miami-Dade County. (2023). *Biscayne Bay Economic Study Update: Final report*. Hazen and Sawyer. https://www.miamidade.gov/environment/library/reports/2023-biscayne-bay-economic-study-update.pdf

[4] Cantillo, A.Y. et al. (2000). Biscayne Bay environmental history and annotated bibliography.

protect shorelines from erosion and storm surges; and coral reefs that host some of the world's richest marine biodiversity and serve as natural barriers to flooding and storm surge.[5]

These ecosystems are not just biologically important; they also serve as natural infrastructure that buffers the region from hurricanes, sea-level rise, and water-quality decline.

Adding to the benefits the Bay provides, public perception studies consistently show that residents strongly value the Bay, not only for its ecological functions, but also as a cultural cornerstone. Survey data indicate that the Bay's role as an ecosystem and its connection to Miami's identity were rated even higher than its contribution to the economy, underscoring its multidimensional significance.[6]

Despite its environmental, economic, and cultural significance, Biscayne Bay is in a state of decline. A 2020 Miami-Dade County report identified a rapid loss of seagrass meadows,[7] which serve as an indicator for broader ecosystem health. Scientific literature and agency monitoring link this loss to chronic and acute nutrient loading, carried into the Bay in part by poorly managed stormwater runoff.

Stormwater runoff is precipitation that flows over land rather than being absorbed, particularly over impervious surfaces such as roads, roofs, and parking lots. As it flows, stormwater picks up a wide range of pollutants, including nutrients from fertilizers and pet waste, heavy metals, oil, sediments, trash, and automotive byproducts from roads.[8] A portion of stormwater in Miami-Dade is discharged into the Bay. This runoff is now understood to be a major driver of eutrophication, a process in which excessive nutrients lead to decreased oxygen levels, algal blooms, fish kills, and widespread habitat loss.

Algal blooms can block sunlight from reaching underwater plants, such as seagrasses, which are essential for stabilizing sediments and supporting marine life. Oxygen depletion can also suffocate fish, shellfish, and other aquatic organisms, leading to fish kills and the collapse of

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[5] Bryan, D. R., J. Luo, and J. S. Ault. (2022). Natural resource condition assessment: Biscayne National Park. Natural Resource Report NPS/BISC/NRR—2022/2252. National Park Service, Fort Collins, Colorado. https://doi.org/10.36967/nrr-2289813.

[6] Wester, J. (2023) Public perception of an important urban estuary: Values, attitudes, and policy support in the Biscayne Bay-Miami Social Ecological System. PLOS ONE 18(10): e0287930. https://doi.org/10.1371/journal.pone.0287930

[7] Biscayne Bay Task Force. (2020). *A unified approach to recovery for a healthy & resilient Biscayne Bay: Report and recommendations.* https://www.miamidade.gov/commission/library/reports/biscayne-bay-task-force-final-report.pdf

[8] Badruzzaman, M., Pinzon, J., Oppenheimer, J., & Jacangelo, J. G. (2012). Sources of nutrients impacting surface waters in Florida: A review. Journal of Environmental Management, 109, 80–92. https://doi.org/10.1016/J.JENVMAN.2012.04.040

sensitive habitats.[9] Over time, eutrophication can change the Bay's ecosystem, from clear, seagrass-dominated waters to murky, algae-dominated waters that support less biodiversity.

The effects of stormwater pollutants are expected to increase in the future. The impacts of climate change and continued urban development can intensify stormwater-related threats. More frequent and intense rainfall events, rising sea levels, and the expansion of impervious surfaces increase runoff volumes, overwhelm aging infrastructure, and exacerbate flooding and water quality problems. These combined pressures can strain existing stormwater systems and heighten the risk of nutrient pollution and habitat loss. A regional study of the Southeast Florida Coastal Basin projects that by the mid-to-late 21st century, annual stormwater runoff could increase by 47% to 87%.[10]

Combined with outdated infrastructure and inconsistent compliance with stormwater permit requirements, these trends place Biscayne Bay and the communities that depend on it at a growing risk of further decline. Effective stormwater management is not just a regulatory obligation—it is essential to the long-term health of Biscayne Bay.

# 4. Stormwater Regulation and the Role of MS4 Permits

Effective stormwater management is essential in Miami-Dade County. A key regulatory framework for controlling stormwater runoff is the MS4 permit, issued under the Clean Water Act's (CWA) National Pollutant Discharge Elimination System (NPDES) program.[11] The CWA, passed in 1972, established a structure for regulating the discharge of pollutants into U.S. waters. When amended in 1987, the NPDES program was expanded to include stormwater discharges from municipal and industrial sources.

MS4 systems are networks of local government-owned and operated storm drains, gutters, ditches, swales, and detention basins designed to collect and convey stormwater, discharging it into rivers, lakes, canals, or coastal waters. To mitigate pollution from these systems, operators must obtain an NPDES MS4 permit and develop a Stormwater Management Program (SWMP) that outlines how they will reduce pollutants in stormwater to the maximum extent practicable.

[9] Haque, S. E. (2023). The effects of climate variability on Florida's major water resources. *Sustainability, 15*(14), 11364. https://doi.org/10.3390/su151411364
[10] Haque, 2023.
[11] 33 U.S.C. § 1342.

The U.S. Environmental Protection Agency (EPA), the regulatory authority over CWA, has delegated NPDES permitting authority to the Florida Department of Environmental Protection (FDEP). All MS4 operators, including Miami-Dade County and 32 co-permittees, as well as the cities of Miami and Hialeah (each individually permitted), are subject to this regulation.

The MS4 permit is a cornerstone of urban stormwater regulation. It requires municipalities to address pollution prevention across various urban systems and activities through a range of control measures.

1. **The Stormwater Management Program (SWMP)**
   Guides municipalities in their stormwater work and compliance with MS4 stormwater permit requirements.
2. **Public Education and Outreach**
   Informs residents and businesses about the impacts of stormwater pollution and encourages behaviors that reduce runoff contamination (e.g., proper pet waste disposal, reduced fertilizer use).
3. **Illicit Discharge Detection and Elimination**
   Requires municipalities to identify and eliminate unauthorized discharges (e.g., sewage leaks and dumping) into the storm sewer system through inspections, enforcement, and public reporting systems.
4. **Construction Site Stormwater Runoff Control**
   Requires documentation and reporting of stormwater management practices, verification that all activities requiring construction permits have the appropriate permits, implementation of erosion and sediment control measures, and periodic site inspections to ensure compliance.
5. **Pollution Prevention and Good Housekeeping**
   Establishes minimum standards for the maintenance of various components of the MS4, including street sweeping, catch basins, and other stormwater infrastructure, to reduce pollution.

The MS4 permits are critical for effective urban stormwater management. In places like Miami-Dade County, where stormwater discharges directly into sensitive ecosystems such as Biscayne Bay, compliance with MS4 requirements is both a legal obligation and an environmental imperative.

However, the effectiveness of the MS4 program depends on how well municipalities implement and maintain their stormwater management efforts. Proper implementation includes timely reporting, adequate infrastructure mapping, robust inspection regimes, and genuine community engagement.

# 5. Methodology

## Overall grading

This report analyzes the performance of Miami-Dade County, its 32 co-permittees, and two individually permitted municipalities—the City of Miami and the City of Hialeah—to evaluate the level of compliance with the MS4 Phase I permits.[12] The review covered permit Years 4 through 6 (2021–2023) of the current MS4 reporting cycle.

This report serves as a follow-up to *An Audit of Miami-Dade County Stormwater Permit Compliance*,[13] published by Miami Waterkeeper and the Everglades Law Center in 2022. The original report evaluated municipal compliance using 2020 data (Year 3 of the MS4 reporting cycle) and established a baseline assessment of stormwater program performance across Miami-Dade County. To ensure consistency and allow for meaningful comparisons over time, this follow-up report applies the same evaluation framework and scoring criteria used in the 2022 audit, while expanding the analysis to include additional years of MS4 reporting data. This approach allows the report to track trends in compliance, assess progress on previous recommendations, and identify ongoing gaps and emerging priorities for improving stormwater management across municipalities.

This compliance evaluation relied exclusively on the following MS4 documents generated by the respective municipalities:

- Annual Reports and their respective attachments
- Written Stormwater Management Programs (SWMPs)
- Stormwater system maps, including major outfall locations

We obtained some of these documents from the Florida Department of Environmental Protection (FDEP) through its Oculus Portal. However, due to incomplete or unavailable uploads in some cases, we submitted public records requests directly to municipalities to obtain the missing materials.

After collecting all available documentation, six independent evaluators assessed each municipality's level of compliance using a standardized rubric (see Annex I for the complete rubric). We developed a rubric based on the requirements outlined in the MS4 Phase I permit, including specific benchmarks, such as the percentage of inspections required for various types of stormwater infrastructure, the expected frequency and quality of system mapping, the

[12]Miami-Dade County and Co-permittees permit is FLS000003, the City of Miami's permit is FLS000002, and the City of Hialeah, FLS000023.
[13] See n. 2.

presence and implementation of illicit discharge detection and elimination programs, and the scope of public education and outreach activities. With two types of scoring systems, quantitative and qualitative, the rubric ensures a comprehensive assessment across all major permit components:

1. **Quantitative Assessment** – A binary scoring system where a value of 1 was assigned for the presence of a required document or action (e.g., submission of an Annual Report), and 0 for its absence.

2. **Qualitative Assessment** – A scaled evaluation that can range from 0 to 3, depending on the category, of the quality and substance of compliance, considering whether the permittees met the requirement with sufficient detail, effort, and clarity.

Each evaluator scored all municipalities independently. Once the individual assessments were complete, the evaluation team reviewed and discussed the results. In cases of disagreement, particularly in qualitative categories, evaluators worked collaboratively to reach consensus. We used a simple average of the submitted scores when the scoring team could not reach consensus.

Each municipality was assigned three final scores: a quantitative compliance score, a qualitative compliance score, and a combined overall score, which was the average of the two. These scores form the basis for comparison across municipalities and over time, including against baseline data from the July 2022 Stormwater Compliance Report.[14]

The statistical analysis methodology can be consulted in Annex II.

# 6. Results: Municipal Performance and Compliance of MS4 permits

This section evaluates municipal stormwater performance over Years 4–6 (2021–2023) of the permit cycle and compares it to the Year 3 "baseline" established in the July 2022 Stormwater Compliance Report. These comparisons highlight which municipalities are making meaningful

[14] In contrast to the July 2022 Stormwater Compliance Report, which assessed only one reporting year, this report required additional methodological decisions related to multi-year data interpretation. For example, in the rubric category assessing stormwater infrastructure inspections, if a specific structure was recorded and inspected in one year but omitted in subsequent years, we assumed it still existed and assigned a score of 0, reflecting a lack of inspection. Conversely, if a structure appeared for the first time in a later year and was not present in prior reports, we assigned an N/A for the earlier years, assuming the infrastructure did not yet exist. This approach reflects the principle that new infrastructure can be added, but existing infrastructure cannot reasonably be assumed to disappear.

progress, which are facing setbacks, and which might require targeted support or enforcement. These findings offer an updated perspective on compliance trends and inform strategies to enhance stormwater management throughout Miami-Dade County.

The stormwater compliance assessment shows a range of municipal compliance across Miami-Dade County (**Table 1**). Out of 34 municipalities assessed from 2021 to 2023 on average, 14 (41%) achieved Excellent (90–100%) or Good (80–89%) ratings, indicating strong compliance with MS4 permit requirements. Twelve municipalities (35%) scored Moderate (70–79%), suggesting that improvements are still needed. Eight municipalities (24%) fell into the Low (60–69%) or Poor (<60%) categories, reflecting significant gaps in stormwater compliance. Overall, while many municipalities demonstrate solid performance, targeted support and enforcement remain necessary for a substantial portion of the analyzed communities.

**Table 1. Municipal Stormwater Permit Compliance Ratings**

| Score Range and Meaning | Municipalities |
|---|---|
| 100% - 90%<br><br>Excellent: The municipality is fully or almost fully compliant with stormwater permit requirements. | Doral, Key Biscayne, City of Miami, Miami Beach |
| 89% - 80%<br><br>Good: Minor gaps, but overall, stormwater permit compliance is strong. | Aventura, Bal Harbour, Coral Gables, Cutler Bay, El Portal, FDOT Turnpike, Golden Beach, Medley, Miami-Dade County, West Miami |
| 79% - 70%<br><br>Moderate: Several improvements are needed to meet full compliance. | FDOT District 6, City of Hialeah, Hialeah Gardens, Homestead, Miami-Dade Expressway, Miami Gardens, Miami Lakes, Miami Shores, North Miami, North Miami Beach, Palmetto Bay, Sunny Isles, Surfside |
| 69% - 60%<br><br>Low: Stormwater compliance is underperforming and may be missing key permit elements. | Indian Creek, Pinecrest, South Miami, Virginia Gardens |

| Table 1. Municipal Stormwater Permit Compliance Ratings | |
|---|---|
| <60%<br><br>Poor: Significant compliance gaps were detected. | Bay Harbor Islands, Miami Springs, North Bay Village, Opa Locka |

This tiered performance breakdown reveals a disparate MS4 compliance landscape across Miami-Dade County.

Before examining individual municipal scores in detail, it is helpful to visualize how stormwater compliance performance is distributed geographically across Miami-Dade County. **Figures 1** and **2** present spatial representations of quantitative and qualitative compliance scores, illustrating how performance varies among municipalities. Coastal and larger municipalities tend to demonstrate stronger overall compliance, such as the City of Miami and Miami Beach, while some smaller inland municipalities, such as Opa Locka and Miami Springs, exhibit more variability and a lower score. The geographic clustering underscores the importance of a coordinated regional strategy to ensure that weaker-performing areas do not undermine broader water quality goals for overall water quality and Biscayne Bay.

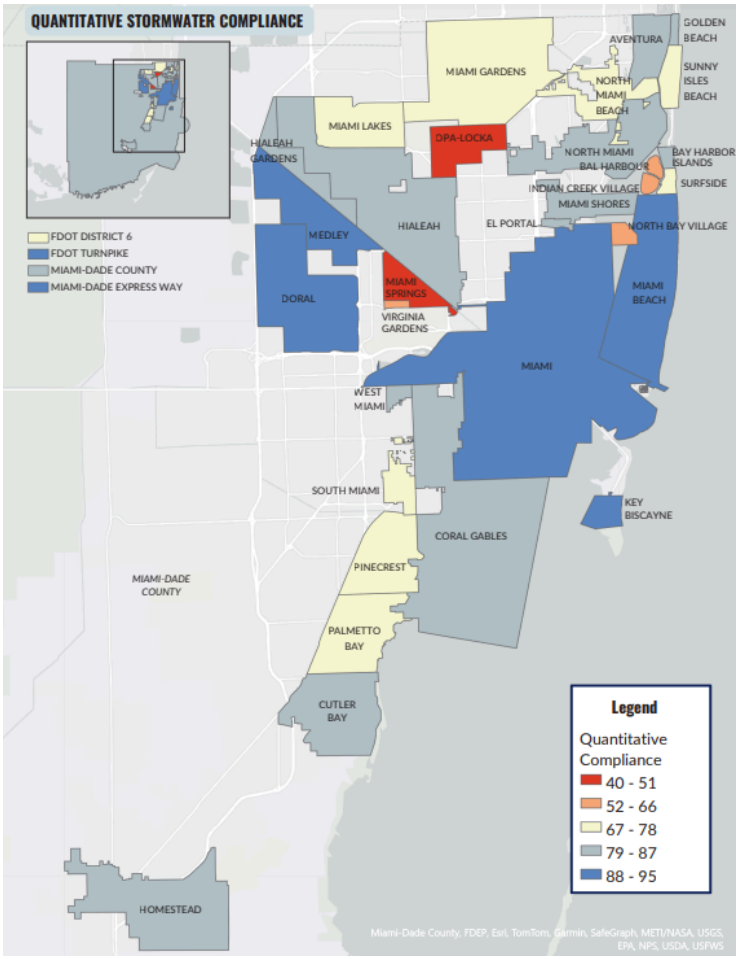



**Figure 1. Overall Quantitative Municipal Stormwater Compliance Scores Across Miami-Dade County (2021–2023).**

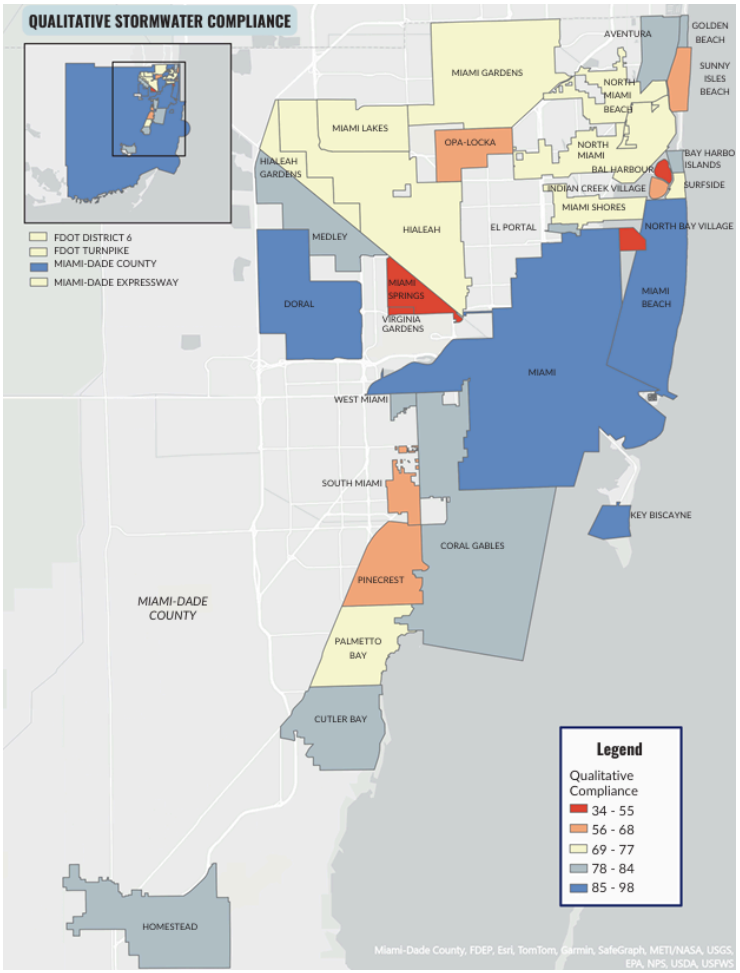



**Figure 2. Overall Qualitative Municipal Stormwater Compliance Scores Across Miami-Dade County (2021–2023).**

**Table 2** compares municipal quantitative and qualitative compliance scores for 2021–2023 with the 2020 baseline. Looking at both types of scores and how they have changed over time helps show which municipalities are improving, which are falling behind, and where compliance gaps remain.

Table 2. Average Quantitative and Qualitative Stormwater Compliance from 2021 to 2023 in Comparison to the 2020 Scores by Municipality

| Municipalities | Average Quantitative Compliance from 2021 to 2023(%)* | Change v. 2020 data | Average Qualitative Compliance from 2021 to 2023 (%)* | Change v. 2020 data |
|---|---|---|---|---|
| Aventura | 79 | 0 | 81 | 0 |
| Bal Harbour | 84 | +12 | 80 | +15 |
| Bay Harbor Islands | 59 | -6 | 53 | -8 |
| Coral Gables | 81 | +2 | 80 | -2 |
| Cutler Bay | 86 | +8 | 83 | +13 |
| Doral | 93 | -2 | 90 | +3 |
| El Portal | 87 | +25 | 79 | +9 |
| Florida Department of Transportation District 6 | 70 | -11 | 71 | -9 |
| Florida Department of Transportation Turnpike | 87 | +16 | 71 | -4 |
| Golden Beach | 84 | +13 | 82 | +13 |
| City of Hialeah | 81 | +5 | 72 | +3 |
| Hialeah Gardens | 81 | +16 | 71 | +14 |
| Homestead | 80 | +4 | 78 | +8 |
| Indian Creek | 65 | -4 | 59 | +1 |
| Key Biscayne | 94 | -1 | 96 | +3 |
| Medley | 90 | +18 | 84 | +11 |
| City of Miami | 91 | +12 | 96 | +7 |
| Miami Beach | 95 | +15 | 98 | +13 |
| Miami-Dade County | 87 | +7 | 88 | +6 |

| Table 2. Average Quantitative and Qualitative Stormwater Compliance from 2021 to 2023 in Comparison to the 2020 Scores by Municipality | | | | |
|---|---|---|---|---|
| Miami Gardens | 78 | +11 | 77 | +15 |
| Miami-Dade Expressway | 72 | +7 | 74 | +9 |
| Miami Lakes | 77 | +1 | 77 | +3 |
| Miami Shores | 81 | +12 | 75 | +9 |
| Miami Springs | 40 | -7 | 34 | -15 |
| North Bay Village | 60 | -12 | 55 | -12 |
| North Miami | 81 | -8 | 76 | -6 |
| North Miami Beach | 72 | +7 | 73 | +5 |
| Opa-Locka | 51 | +7 | 60 | +13 |
| Palmetto Bay | 73 | +10 | 72 | +12 |
| Pinecrest | 70 | +3 | 67 | +10 |
| South Miami | 73 | -2 | 64 | -4 |
| Sunny Isles Beach, Florida | 74 | +13 | 68 | +11 |
| Surfside | 74 | +5 | 74 | +10 |
| Virginia Gardens | 66 | +19 | 54 | +15 |
| West Miami | 81 | +14 | 80 | +23 |

When graded on the quantitative compliance standard, the average from 2021 to 2023 for Miami-Dade County and its 32 Co-permittees was 76.5%, which corresponds to a grade C, the City of Miami had a 91% score which represents an A-, and the City of Hialeah had an 81% grade corresponding to a B-. When graded on qualitative compliance, the overall average for Miami-Dade County and its 32 Co-permittees was 73.8%, representing a C. The City of Miami received a score of 96%, amounting to an A, and the City of Hialeah received a score of 72%, which represents a C-.

When compared to the 2020 baseline, the average municipal stormwater compliance from 2021 to 2023 improved from 68.7% to 75.1% during permit Years 4–6, reflecting some measurable progress in overall compliance performance across municipalities. Many municipalities, including El Portal, Medley, West Miami, and Miami Beach, recorded

substantial increases in both quantitative and qualitative scores, reflecting improvements in documentation, reporting completeness, and the updating of stormwater planning materials.

In contrast, several municipalities, such as Miami Springs, North Bay Village, and Bay Harbor Islands, declined relative to 2020, indicating that improvements were not uniformly sustained. Notably, the strongest gains appear concentrated in administrative and planning-related categories such as updating or creating a SWMP and a complete stormwater map, rather than in routine field-based activities like inspections and maintenance, which continue to show variability across jurisdictions. Municipalities that were already strong performers in 2020 generally maintained high scores with smaller gains, underscoring that moving from good to excellent compliance requires sustained operational rigor rather than one-time administrative improvements.

Overall, Table 2 suggests that while progress since 2020 does exist, there are still multiple municipalities and compliance areas that require improvement in compliance. The next phase of improvement will depend on translating planning advances, such as Stormwater Management Plans and Infrastructure maps into consistent on-the-ground implementation like consistent inspections and maintenance, to mention an example, capable of delivering measurable environmental benefits for Biscayne Bay.

## Stormwater Results by Category

This section presents the results of our stormwater compliance assessment across all rubrics.[15]

## Annual Reports Submitted

One of the central requirements of the MS4 permit is the obligation for all permittees to submit annual reports documenting compliance with permit conditions and stormwater management activities to the Florida Department of Environmental Protection. Annual reporting is a core component of the MS4 program because it provides regulatory agencies and stakeholders with transparency into municipal stormwater practices, enables tracking of environmental progress, and supports adaptive management when deficiencies are identified.

On average, during the analyzed period from 2021 to 2023, 97.1% of permit holders met the basic requirement of submitting their annual report, a percentage that did not differ from 2020, the baseline year.

Although overall submission remained high, isolated gaps occurred, where no reports were submitted by some municipalities as seen in **Figure 3.** North Bay Village did not submit a report in 2021, and reports were also absent from Bay Harbor Islands and Miami Springs in 2023. These gaps highlight that while procedural compliance is generally strong, continued attention to reporting consistency and completeness is essential to ensure the MS4 program's objectives of accountability and data-driven environmental management are fully supported.

[15] Statistical tests were conducted to evaluate whether compliance scores changed significantly across years for both quantitative and qualitative rubrics. For quantitative metrics, Fisher's Exact Tests showed no statistically significant differences over time, indicating that most changes observed in the plots reflect gradual improvements rather than sharp year-to-year shifts. For qualitative metrics, Kruskal–Wallis tests revealed two rubrics with statistically significant differences: completion of Stormwater Management Programs (complete_SWMP, $p = 0.041$) and stormwater outfall mapping (map_outfall, $p < 0.001$). These results support visual trends showing substantial improvement in the quality and completeness of SWMPs and mapping efforts, while other rubrics remained relatively stable during the evaluation period.

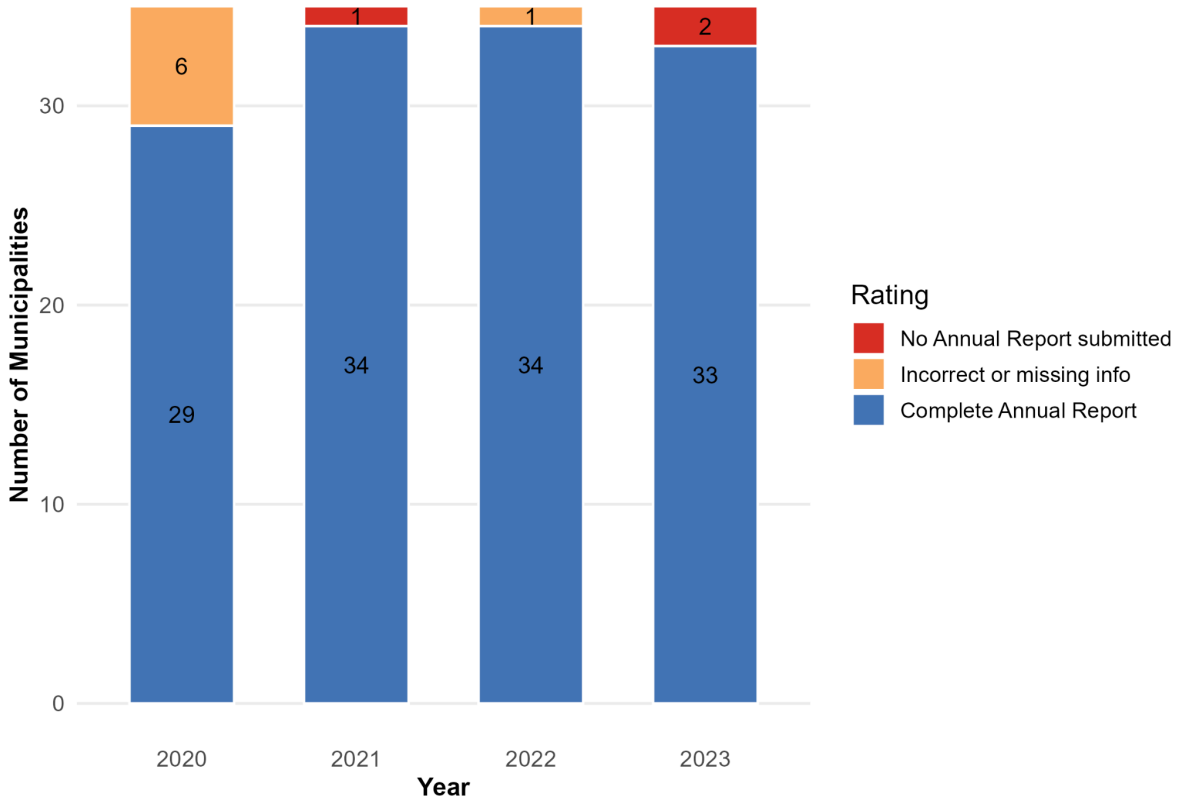



**Figure 3. Annual Report Qualitative Submission Rates (2020–2023).**

## Written Stormwater Management Program (SWMP)

The Stormwater Management Program (SWMP) is a municipality's blueprint for meeting its MS4 stormwater permit requirements. A well-prepared and updated SWMP is critical because it serves as the guiding document for stormwater compliance and helps municipalities proactively manage flooding and pollution risks in their communities. In 2020, 19 municipalities did not have or had outdated SWMPs, that had been written over 10 years ago. This can limit their ability to demonstrate compliance or plan for long-term stormwater management. Over the next three years, the proportion of municipalities that had a SWMPs increased from 54.5% in 2020 to 77.1% by 2023, showing clear progress in municipalities having adopted a SWMP. This improvement suggests that more cities are allocating time to document their stormwater strategies and plan future compliance efforts. However, over the analyzed period we still found eight municipalities that did not have a SWMP; these were: Coral Gables, Hialeah Gardens, Indian Creek, Miami Shores, North Miami, South Miami, Sunny Isles, and Virginia Gardens.

Qualitatively, we evaluated how frequently SWMPs were updated. High-scoring municipalities provided more up-to-date SWMPs, while lower-performing municipalities often submitted outdated SWMPs that had not been updated for over ten years in some cases, such as Bay Harbor Islands, City of Hialeah, Miami Springs and Florida Department of Transportation District 6 and the Turnpike.

However, compared to 2020, ten additional municipalities adopted updated SWMPs (**Figure 4**) that were 0 to 5 years old, showing municipalities are investing in having up to date plans to manage stormwater.

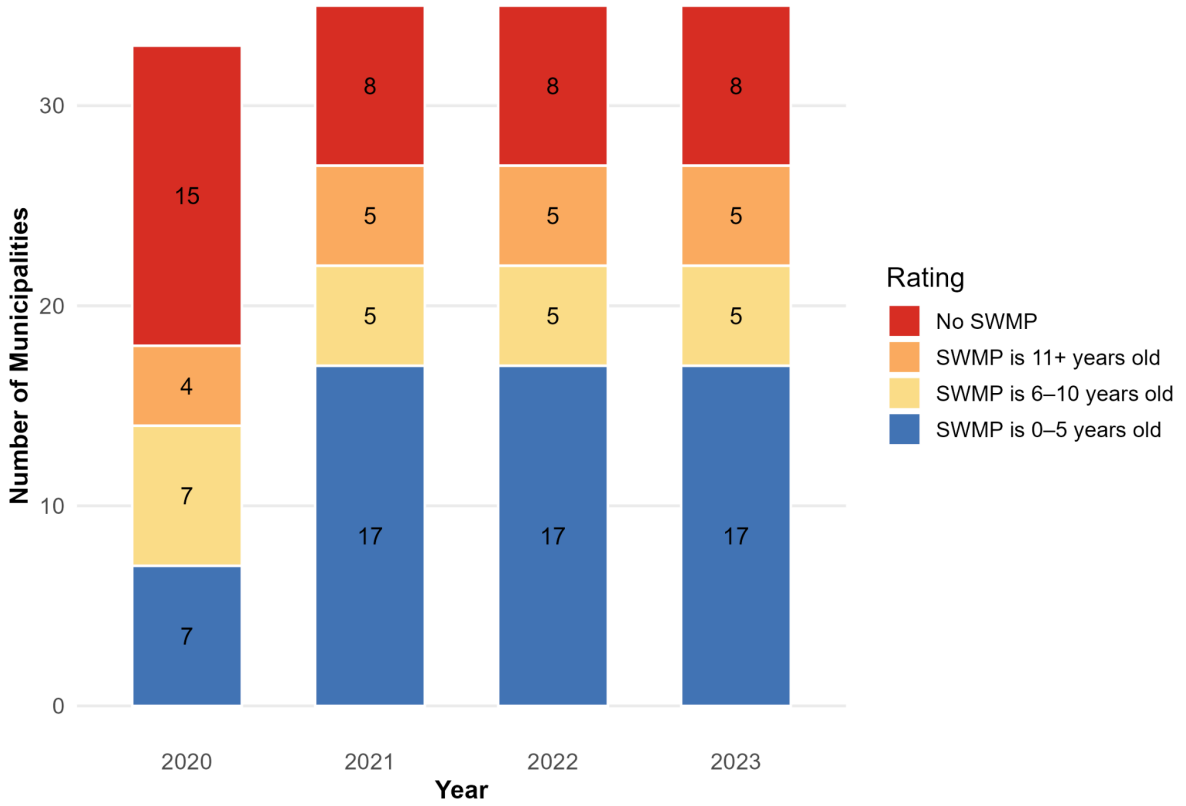



**Figure 4. Qualitative Analysis of SWMP Existence and Periodicity of Updates.**

## Mapping outfalls

One of the most significant areas for improvement among municipalities during the audit period was the completion and accuracy of stormwater system and outfall maps. In 2020, only

57% of municipalities had complete or up-to-date maps, with many either outdated or lacking comprehensive documentation. By 2023, that proportion increased to 88.6%, showing a clear improvement, as most municipalities provided complete maps that identified key infrastructure.

As seen in **Figure 5**, in 2020, 11 municipalities had outdated or incomplete maps and 9 municipalities did not have maps. By 2021, only 4 municipalities lacked a Stormwater map: Miami Lakes, Miami Springs, Virginia Gardens, and West Miami.

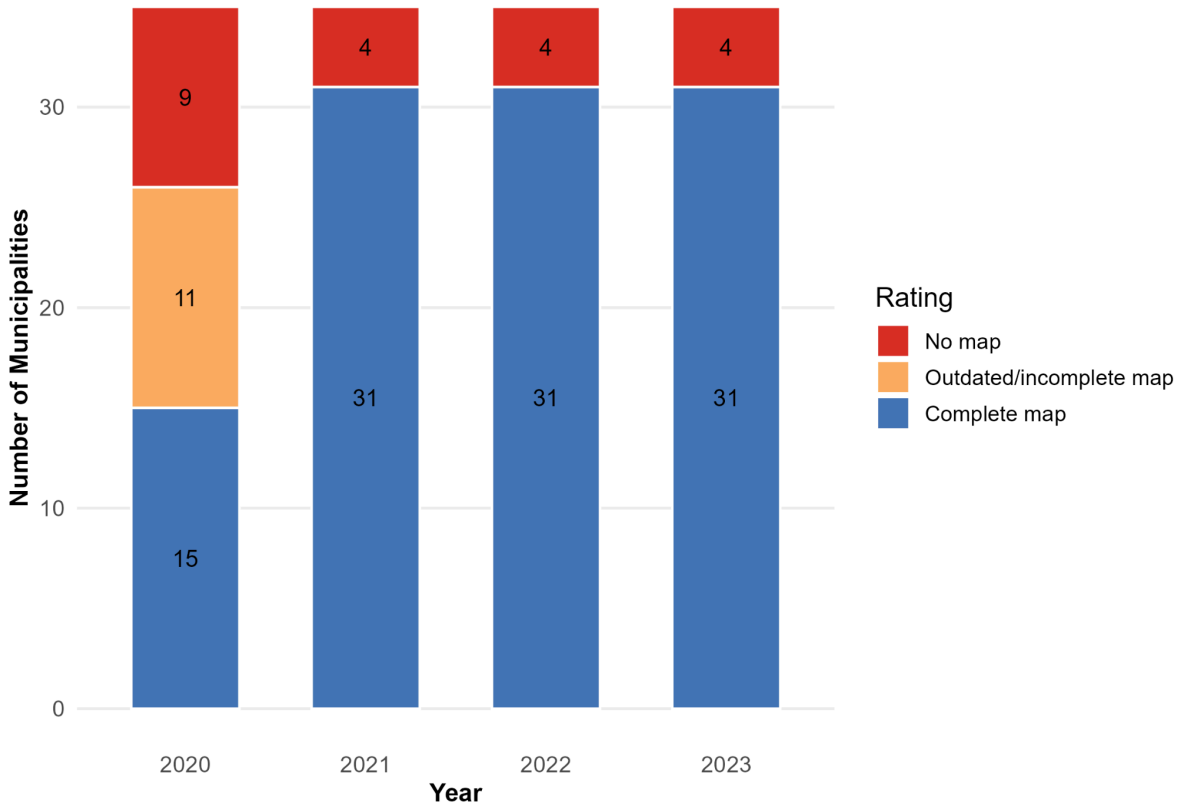



**Figure 5. Qualitative Analysis of Completeness of Municipal Stormwater Maps.**

High-quality mapping is essential because it not only meets MS4 permit requirements but also helps prevent pollution and flooding by providing cities with a clear understanding of where water flows and where interventions are needed most. It also allows municipalities to know where their stormwater infrastructure is located and plan a schedule for proper monitoring, inspection, and maintenance of such infrastructure. This section received some of the best rates of improvement, with only 4 municipalities lacking a map now. As a further goal,

digitization of stormwater maps are critically important to ensure an ability to manage across system with stormwater asset management systems.

## Water Quality Monitoring

Water quality monitoring beyond the county's DERM program is rare. Across all years, most municipalities reported no additional tracking, and only five consistently reported frequent independent monitoring. These were Coral Gables, Key Biscayne, City of Miami, Miami Beach, and Pinecrest. Opa Locka also did some independent monitoring, however this was done sporadically, according to their annual plan (**Figure 6**).

This suggests that while cities are meeting the minimum requirements, few are exceeding them to collect additional data on water quality. Additional local monitoring by municipalities could detect early signs of pollution, pollution hotspots, or areas that need special attention.

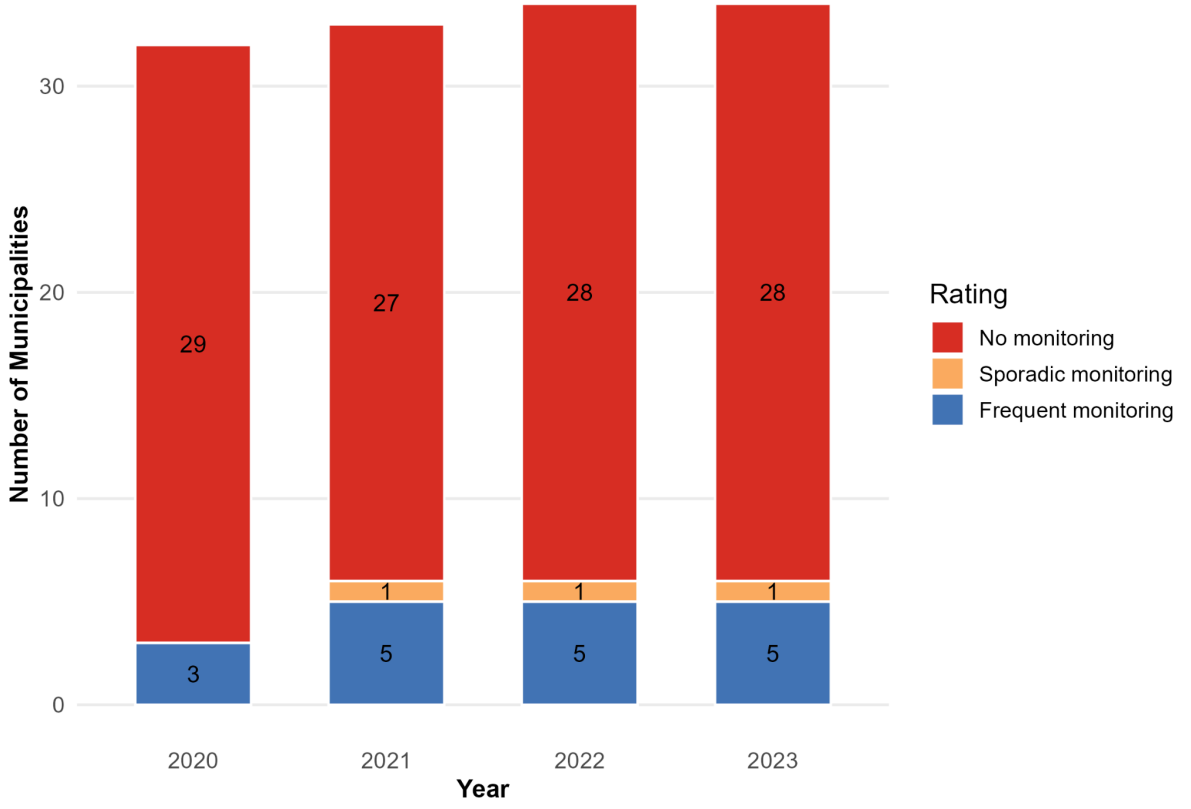



**Figure 6. Municipal Participation in Water Quality Monitoring Beyond County Requirements.**

## Submitted Required Attachments

Annual report attachments give the clearest picture of a city's stormwater infrastructure and mitigation efforts. Consistent and complete documentation makes it easier to identify gaps in the system and plan upgrades to mitigate flooding and pollution. Each year of the permit cycle, permittees are required to submit specific attachments that provide additional information. For example the third year of the permit cycle, permittees must submit the estimates of annual pollutant loadings of certain parameters, such as Phosphorus and Nitrogen. In the fourth year, permittees must submit the existing Monitoring Plan, including any suggested changes to improve the plan.

The submission of required attachments to the annual reports, including maps and supporting documents, improved temporarily after 2020 but fluctuated. By 2022, five additional municipalities had submitted all of their attachments in comparison to the baseline year (2020); however, by 2023, there was a slight backslide, with ten municipalities neglecting to submit attachments (**Figure 7**). The municipalities that did not submit their attachments were Bay Habor Islands, Doral, Miami Gardens, Miami Springs, North Miami, North Miami Beach, Palmetto Bay, South Miami, Virgina Gardens and West Miami.

Municipalities are not required to submit additional attachments after Year 5 of the permit cycle. Under the MS4 permit structure, each year of a permit cycle carries different attachment submission requirements that build on one another over time. In addition to submitting an annual report every year, permittees must include specific supporting attachments that vary depending on which year of the cycle they're in. For example, Year 3 requires estimates of annual pollutant loadings, while Year 4 requires submission of the existing Monitoring Plan along with any suggested revisions. Importantly, once a permit cycle reaches Year 5, no further additional attachments are required, signaling that the cycle has run its course and the permit needs to be renewed by FDEP to reset the clock and continue collecting meaningful supplementary data. Without timely renewal, this attachment-based reporting is limited, impacting the regulators' ability to track compliance trends, assess stormwater infrastructure, and identify municipalities that may need additional support or enforcement.[16]

[16] By the date this report is published the current permit year will be going into its 9 or 10th year of the cycle, depending on the Permit.

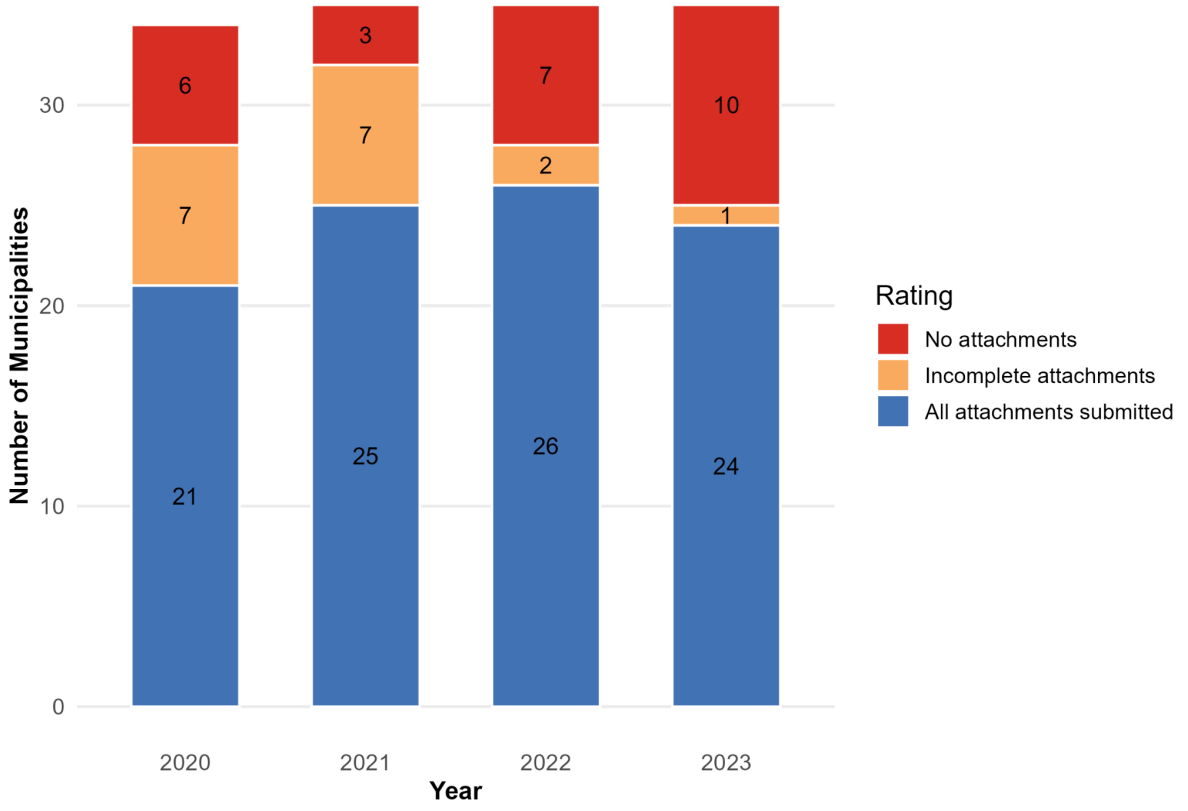



**Figure 7. Qualitative Analysis of Submission and Completeness of Supporting Documentation Submitted.**

## Inspections of Stormwater Structures

Municipalities are required to conduct routine inspections of structural stormwater features, including retention ponds, swales, and conveyance systems, to ensure proper function and prevent system failure. These inspections are the primary mechanism for identifying sediment accumulation, blockages, structural deterioration, and illicit discharges before they escalate into localized flooding or pollutant releases.

From 2020 to 2023, the share of municipalities completing all required inspections annually

increased from 17 to 23, reflecting a modest but measurable improvement over the baseline.

While there is an upward trend in municipalities completing all required inspections, **Figure 8** demonstrates that throughout the analyzed period nearly one-third of municipalities still failed to meet the permit requirement of inspection of at least 33% of the structures in any given year. Additionally, Indian Creek, Bay Harbor Islands, and Miami Springs did not conduct the required inspections of their structural controls (dry retention, exfiltration trenches, french drains, grass treatment, swales, wet detention, etc.) during the reporting period.

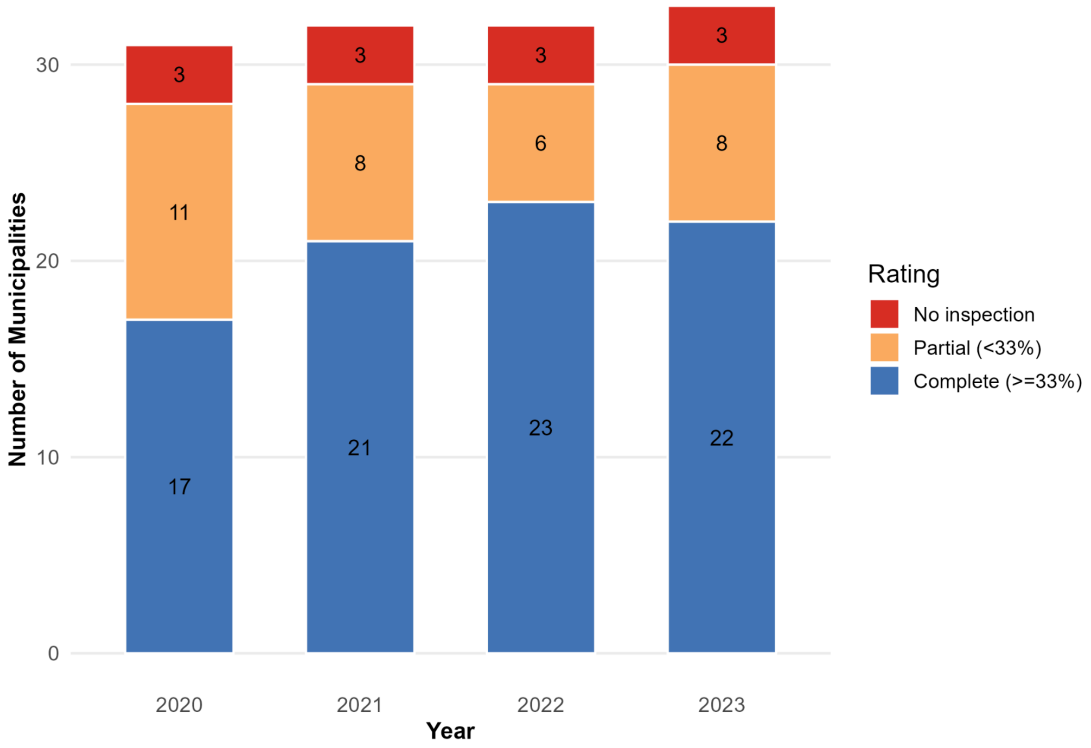



**Figure 8. Qualitative Analysis of Stormwater Structural Inspections.**

## Quarterly Inspections of Pollution Control Boxes

Pollution control boxes are designed to capture trash, sediments, and oils before these pollutants flow downstream into canals, rivers, and Biscayne Bay. Regular inspection and cleaning of these boxes is critical because, when clogged or poorly maintained, they lose their effectiveness.

This requirement is a low-hanging fruit in terms of achieving improvements in both function and pollution control. However, this condition was one of the lowest-performing categories

across all years, showing a decline throughout the analyzed period and relative to the baseline year, as several municipalities either reduced inspection frequency or failed to document the inspections. The percentage of municipalities completing all inspections actually decreased from eight out of 15 municipalities in 2020 to 7 out 17 completing the required inspections of their pollution control boxes in 2023. This represents a decrease from 53.3% in 2020 to 41.2% in 2023.

In **Figure 9** we can see the number of municipalities that did not inspect their pollution control boxes at least quarterly, as the permit requires, and those not inspecting them at all increased over the years. By 2023, Bay Harbor Islands, Cutler Bay, Miami Springs and the Miami-Dade Expressway did not conduct inspections to their pollution control boxes.

Maintaining regular inspections is essential both for compliance with the MS4 permit and for protecting water quality in canals, rivers, and Biscayne Bay.

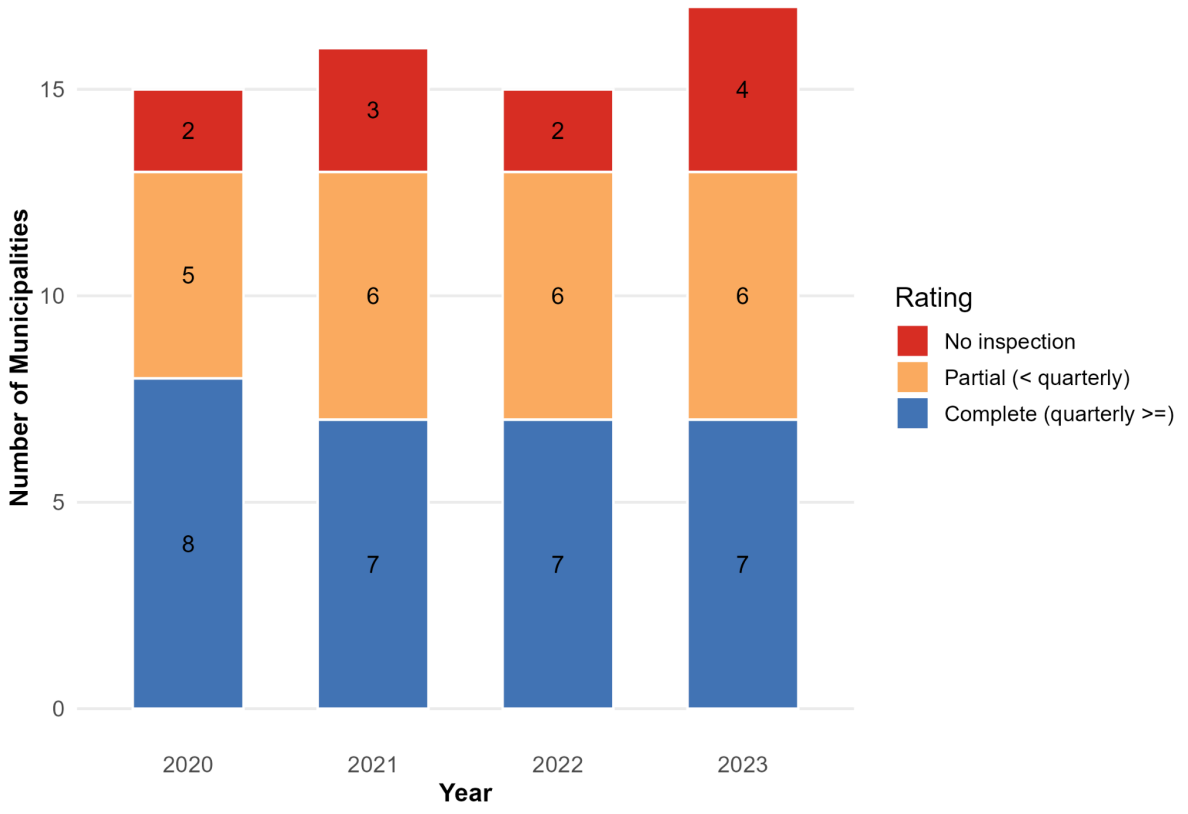



**Figure 9. Qualitative Analysis of Inspection of Pollution Control Box Inspections.**

## Semi-Annual Inspections of Stormwater Pumps

Stormwater pump systems are important components of municipal flood control infrastructure, particularly in low-lying areas where gravity drainage is ineffective. The data show a clear regression since 2020: the percentage of municipalities with this infrastructure inspecting their stormwater pumps declined from 94.1% at the baseline to 78.9% in 2023, the last year of the analysis.

We can see that in 2022 and 2023, three municipalities did not report inspections of pumps at all (**Figure 10**): Miami Springs, North Bay Village, and Virginia Gardens in 2022 and Miami Springs, North Bay Village, and Bay Harbour Islands in 2023.

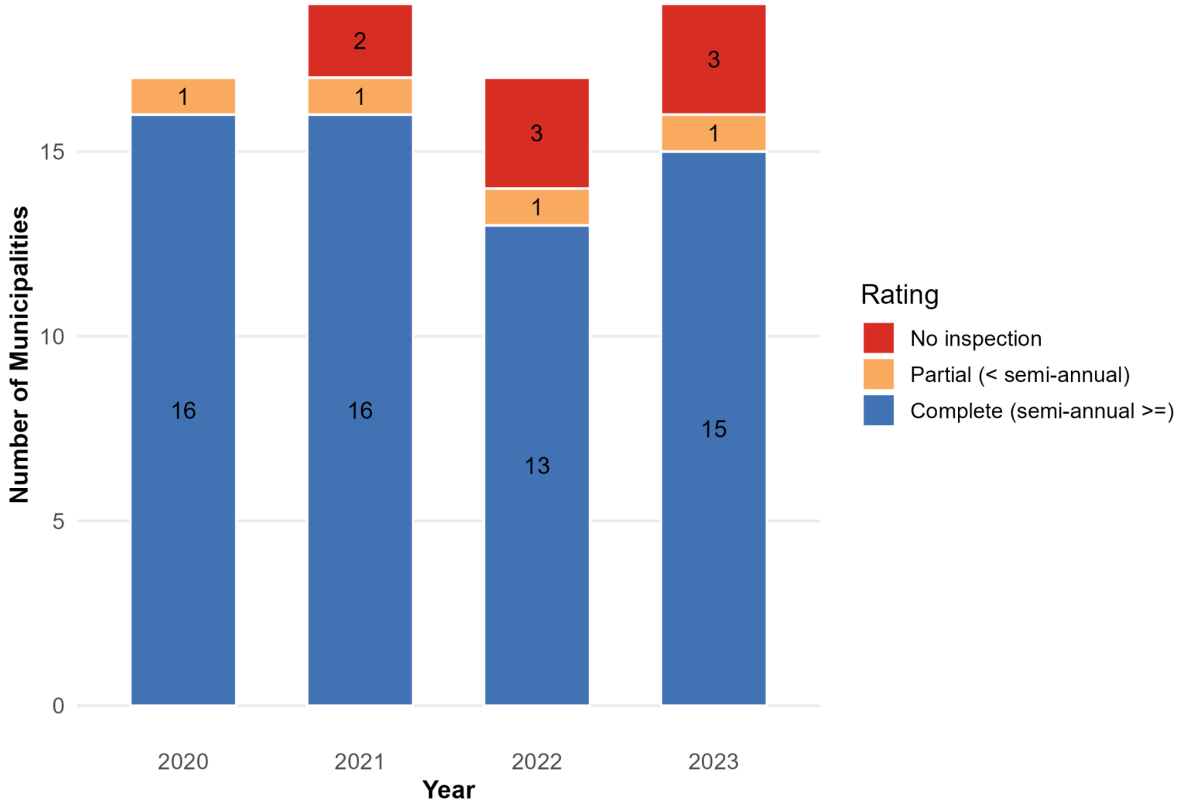



**Figure 10. Qualitative Analysis Stormwater Pump Inspections.**

## Annual Inspections of Major Stormwater Outfalls

Outfall inspections represent a direct line of defense for water quality, as these structures are the final discharge points where stormwater enters canals, rivers, and ultimately Biscayne Bay. Outfall monitoring provides the last opportunity to detect blockages, structural

deterioration, or visible signs of illicit discharge before pollutants reach receiving waters.

In 2022, inspection rates temporarily exceeded 90%, marking a significant improvement relative to both 2021 and 2023, with only Hialeah and Opa-Locka not conducting any kind of inspection. Yet this gain was not sustained in the following year, suggesting that the 2022 increase may have reflected short-term action. The reversion to lower compliance levels, around 78% in 2023, indicates that inspection performance remains vulnerable to fluctuation.

**Figure 11** shows that by the end of the analysed period, five municipalities, Bay Harbour Islands, Hialeah Gardens, Miami Springs, Miami-Dade Expressway, and Opa-Locka were not inspecting their outfalls, creating intermittent oversight of critical discharge points. This represents an increase of municipalities not inspecting their outfalls in comparison to 2022, and to the baseline year 2020.

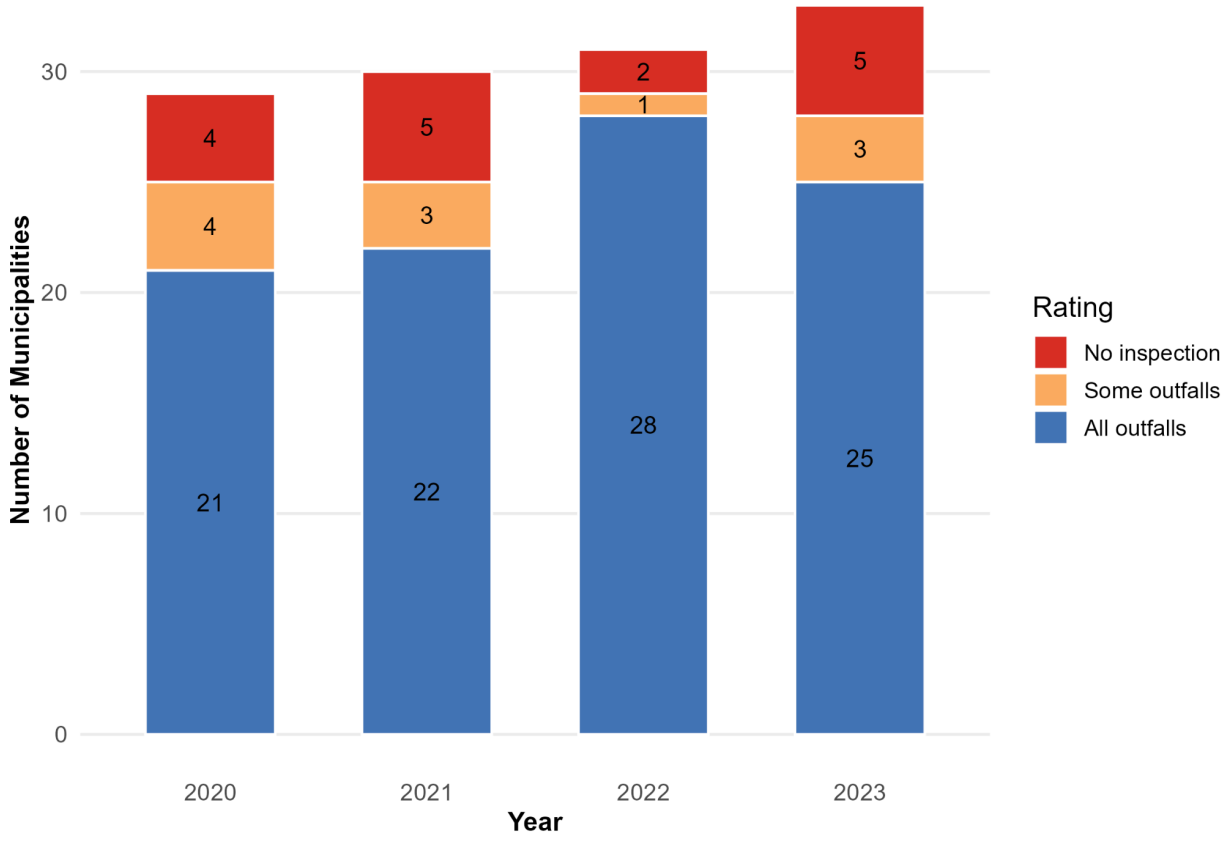



**Figure 11. Qualitative Analysis of Inspection of Stormwater Outfalls.**

## Inspections of Pipes and Culverts

Stormwater pipes and culverts form the backbone of municipal drainage networks, conveying runoff from neighborhoods to larger conveyance systems and discharge points. Because these assets are largely underground and out of view, routine inspection is essential to detect failures. The data indicate a steady erosion in compliance within this category: inspection rates declined by approximately 3% between 2021 and 2023 and by nearly 8% compared to the 2020 baseline.

Over time, an increasing number of municipalities failed to inspect at least 10% of their stormwater pipes and culverts annually (**Figure 12**). By 2023, six municipalities, Bay Harbour Islands, Golden Beach, Indian Creek, Miami Springs, Sunny Isles, and Surfside, did not conduct any inspections.

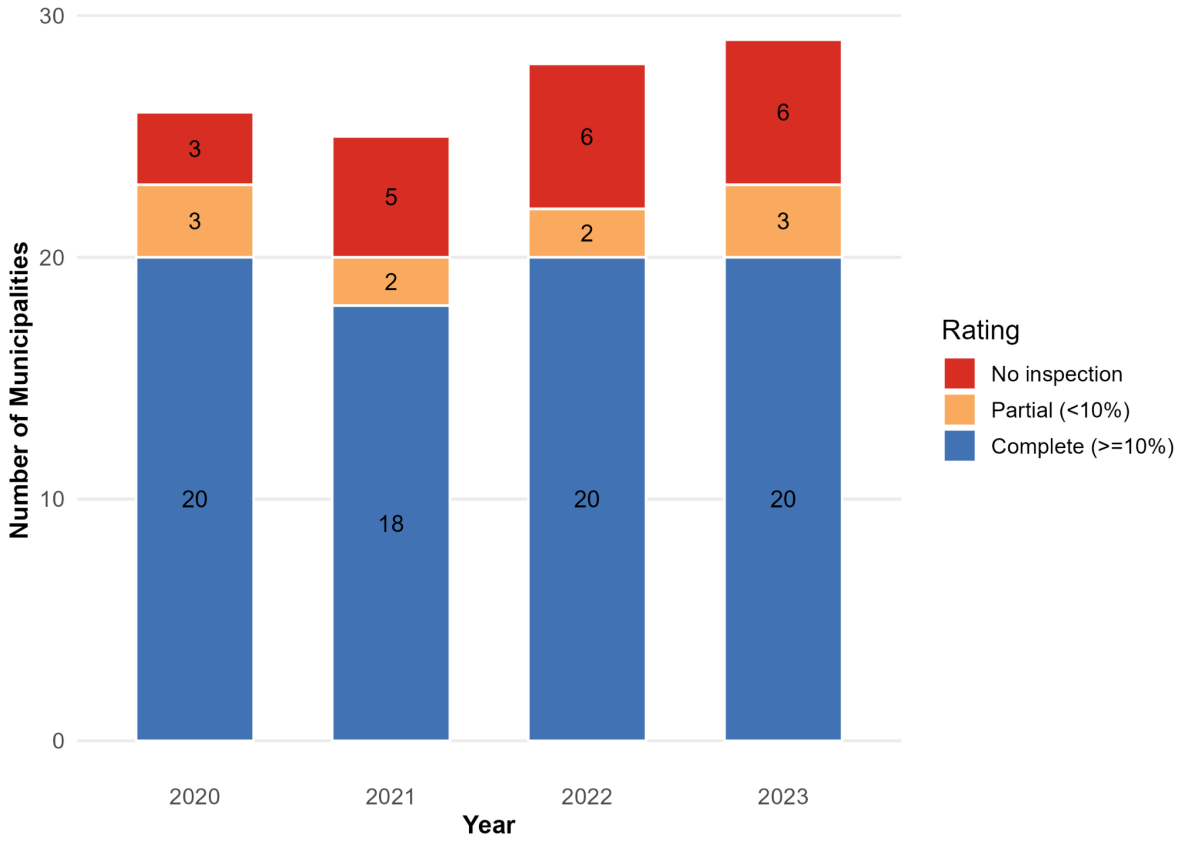



**Figure 12. Qualitative Analysis of Pipes and Culverts Inspections.**

## Inspections of Inlets, Catch Basins, and Conveyances

Inspections of inlets, catch basins, and conveyance structures demonstrated comparatively strong quantitative compliance over the three years, ranging from approximately 83% to 91%, with a mean of 88%, a rate largely consistent with the 2020 baseline. This stability suggests that municipalities have maintained routine oversight of these highly visible and frequently serviced components of the stormwater system.

While most municipalities conducted inspections annually, a subset performed inspections that were incomplete in comparison with the permit conditions that require the inspection of at least 10% of the infrastructure (**Figure 13**). By 2023, there were still some municipalities that did not report inspections of inlets, catch basins and conveyances; these were: Bay Harbor Islands and Miami Springs. Lack of inspections and partial inspections, that do not meet the 10% threshold, suggest that municipalities may not be achieving a comprehensive inspection of the whole system.

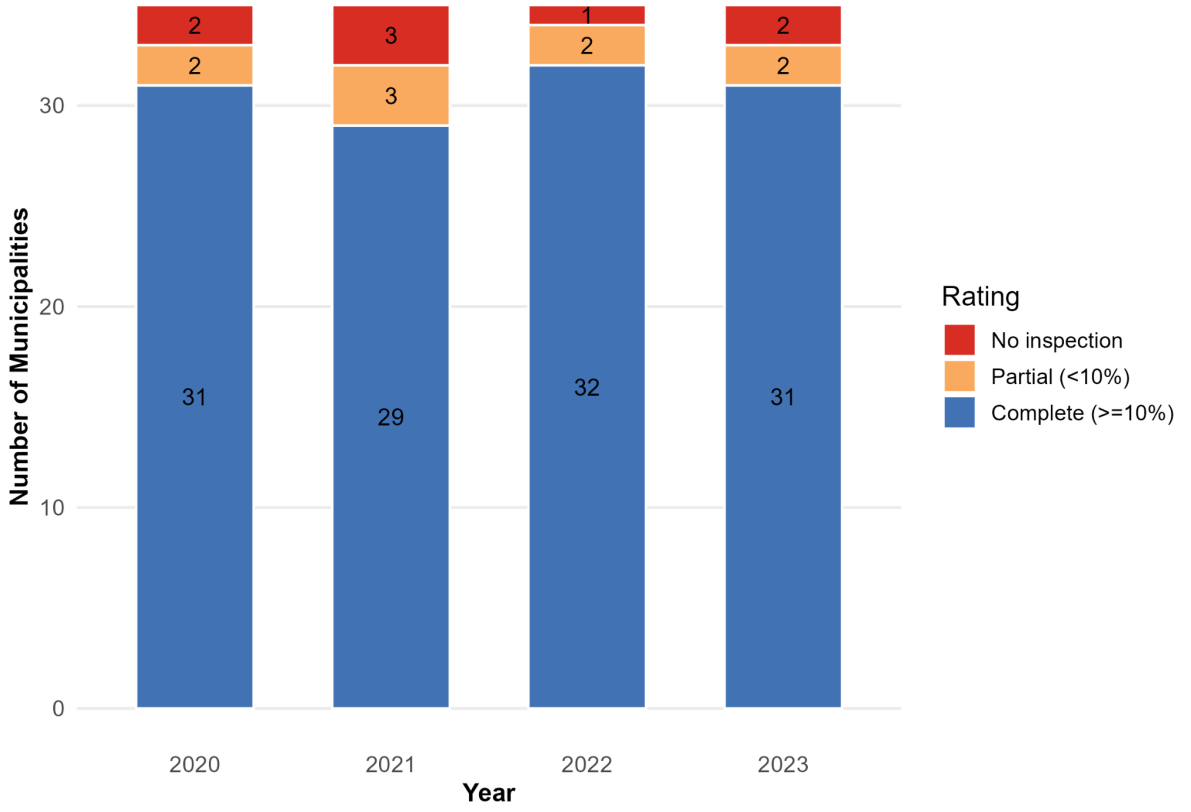



**Figure 13. Qualitative Analysis of Inlets, Catch Basins, and Conveyances Inspections.**

## Litter Control Programs

Nearly all municipalities reported maintaining a litter control program between 2021 and 2023, with compliance rates ranging from 94% to 100%, and there was minimal variation from the baseline year. This sustained high level of reported compliance suggests that litter control is one of the most consistently implemented stormwater program components across jurisdictions. Permittees are required to maintain written

program descriptions, specify collection frequencies for streets and rights-of-way, and document the weight or volume of collected debris.

Closer examination reveals variation in program frequency. While the majority of municipalities conduct weekly street sweeping or litter collection, others operate on bi-weekly or monthly schedules, and a small number did not report their litter control activities (**Figure 14**). The municipalities that did not report any litter collection activities were Bal Harbour and North Bay Village for 2021 and Bay Harbor and Miami Springs for 2023.

While municipalities have largely institutionalized litter control programs, the next phase of improvement should focus on increasing frequency, when necessary, across the County.

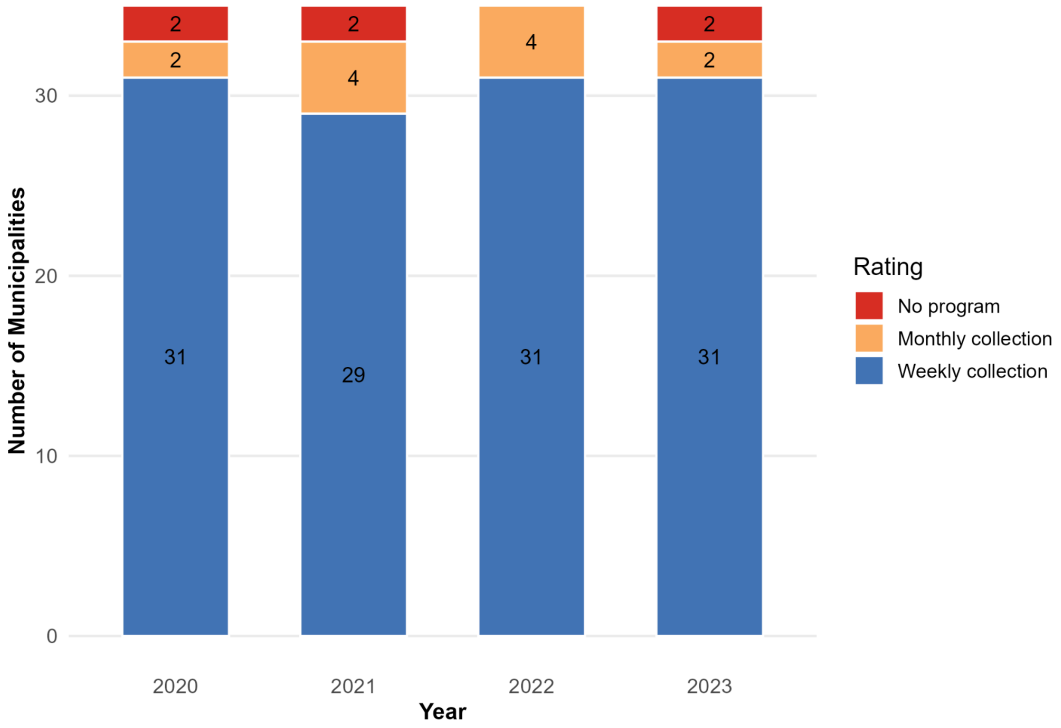



**Figure 14. Qualitative Analysis of Frequency of Litter Control Activities.**

## Street Sweeping Programs

Street sweeping remains widely implemented across municipalities; however, compliance data indicate a measurable decline since the 2020 baseline, with an approximately 8% reduction in reported implementation by 2023. While most municipalities continue to maintain sweeping

programs, the downward shift suggests that what was once near-universal participation has become less consistent over time.

This decline is due to the fact that by 2023, six municipalities did not report having a street sweeping program in place (**Figure 15**). These municipalities were Bay Harbor Islands, Miami Springs, North Bay Village, Opa-Locka, Palmetto Bay, and Pinecrest. Although the majority of municipalities continue to operate on a monthly sweeping schedule, with some conducting bi-weekly or weekly operations, we can still observe a variation on frequency across municipalities.

From a pollution prevention standpoint, frequency can directly influence the amount of sediment, trash, nutrients, and heavy metals removed before rainfall events mobilize these pollutants into the storm drainage system. Municipalities operating on more frequent schedules and maintaining clear tracking documentation demonstrate a stronger preventative management approach.

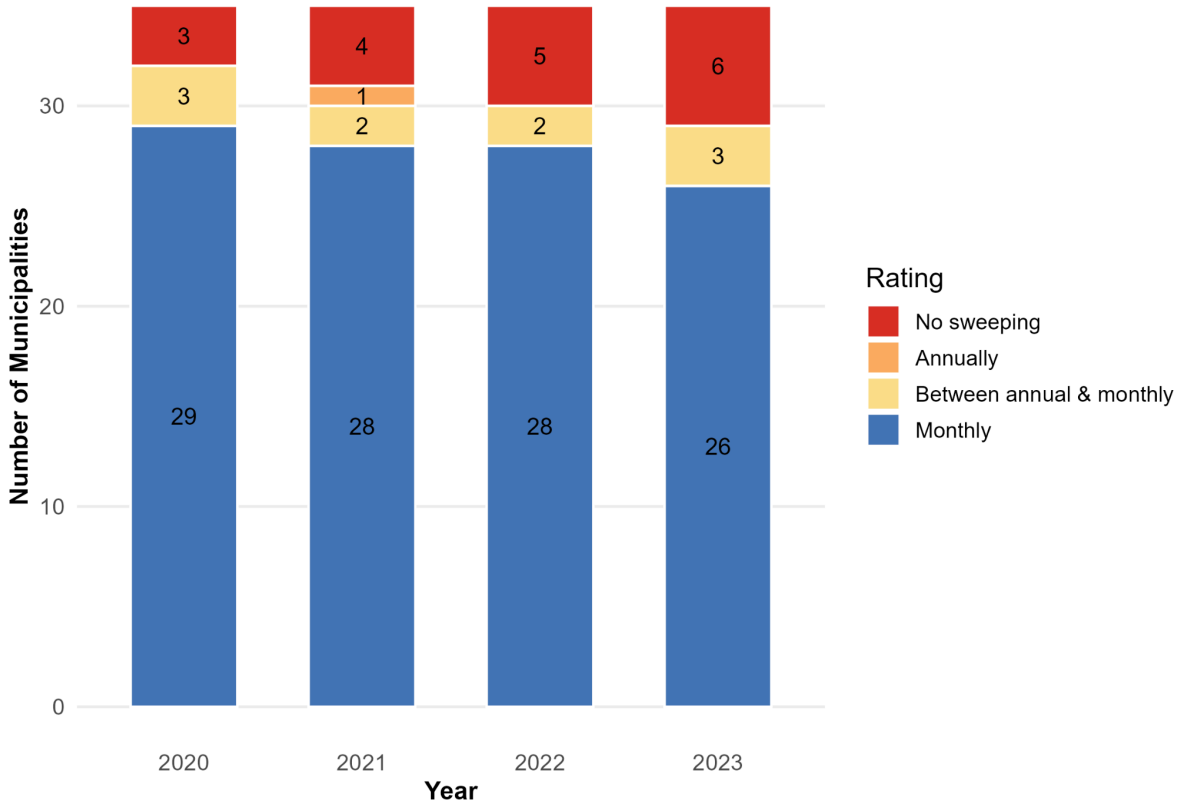



**Figure 15. Qualitative Analysis of Frequency of Street Sweeping Operations.**

## Proactive Illicit Discharge Detection (IDD) Programs

Proactive programs to identify and eliminate illicit discharges remained largely unchanged throughout the analyzed period and relative to the 2020 baseline at around 80% compliance.

By 2023, there was a modest increase in the number of municipalities directly implementing proactive inspection programs rather than relying solely on County-led efforts (**Figure 18**). The stagnation in total inspection numbers, however, suggests that proactive IDD efforts have not yet evolved into targeted, data-driven programs. Effective illicit discharge prevention depends less on inspection volume alone and more on strategic deployment focusing on known problem areas, aging infrastructure, commercial and industrial corridors, and historically documented hotspots.

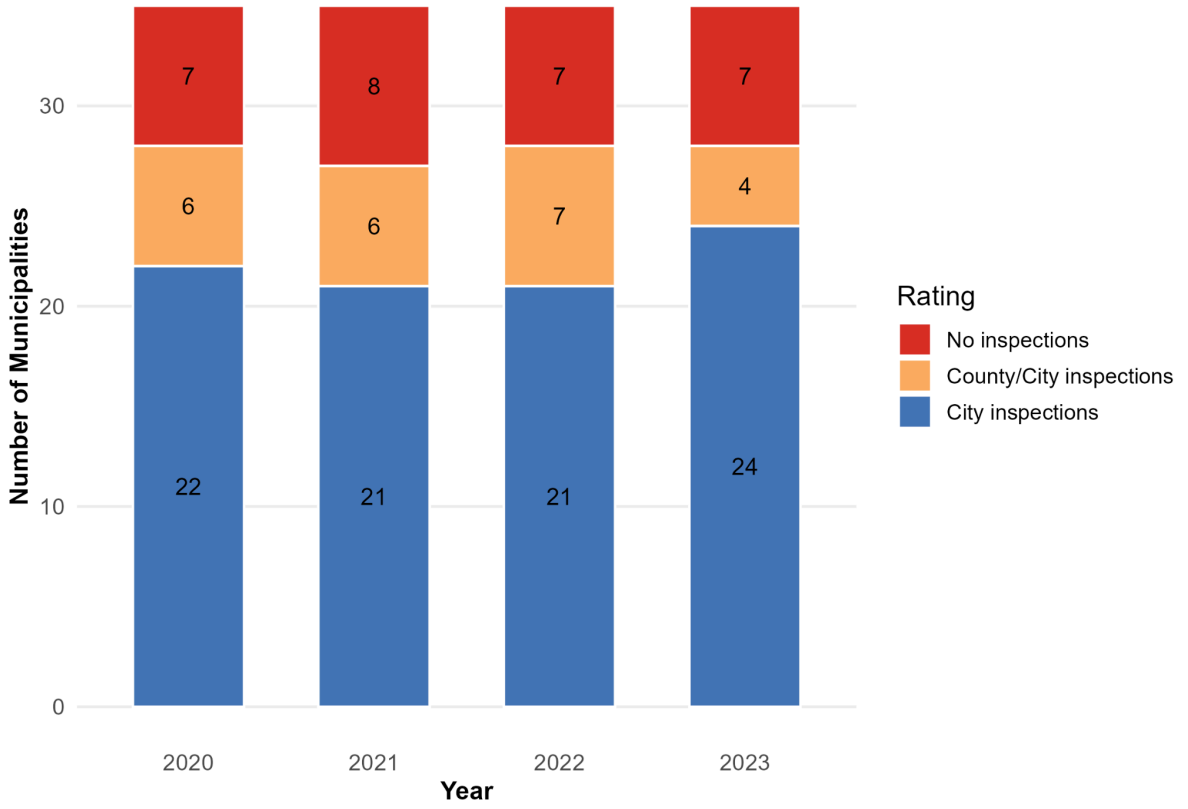



**Figure 16. Qualitative Analysis of Proactive Illicit Discharge Inspections.**

## Reactive Investigations of Illicit Discharges

Municipalities are required to track and report the number of suspected illicit discharge complaints received and the number investigated or resolved. These reactive investigations serve as a critical backstop in stormwater management, ensuring that real-time threats are addressed before they cause sustained environmental harm. The percentage of complaints fully responded to between 2021 and 2023 fluctuated year to year but remained below the 80% of municipalities that in 2020 fully responded to reports. In 2023 73% of municipalities were replying to all reports.

However, qualitative findings provide a more nuanced picture. The majority of municipalities reported responding to complaints upon receipt, and the proportion of complaints that went uninvestigated declined steadily from 2021 to 2023 (**Figure 17**). This trend indicates progress in procedural follow-through.

Sustained progress in this category will require maintaining timely response protocols. Because reactive investigations directly intercept active pollution events, performance in this category has immediate implications for protecting waterways, including Biscayne Bay.

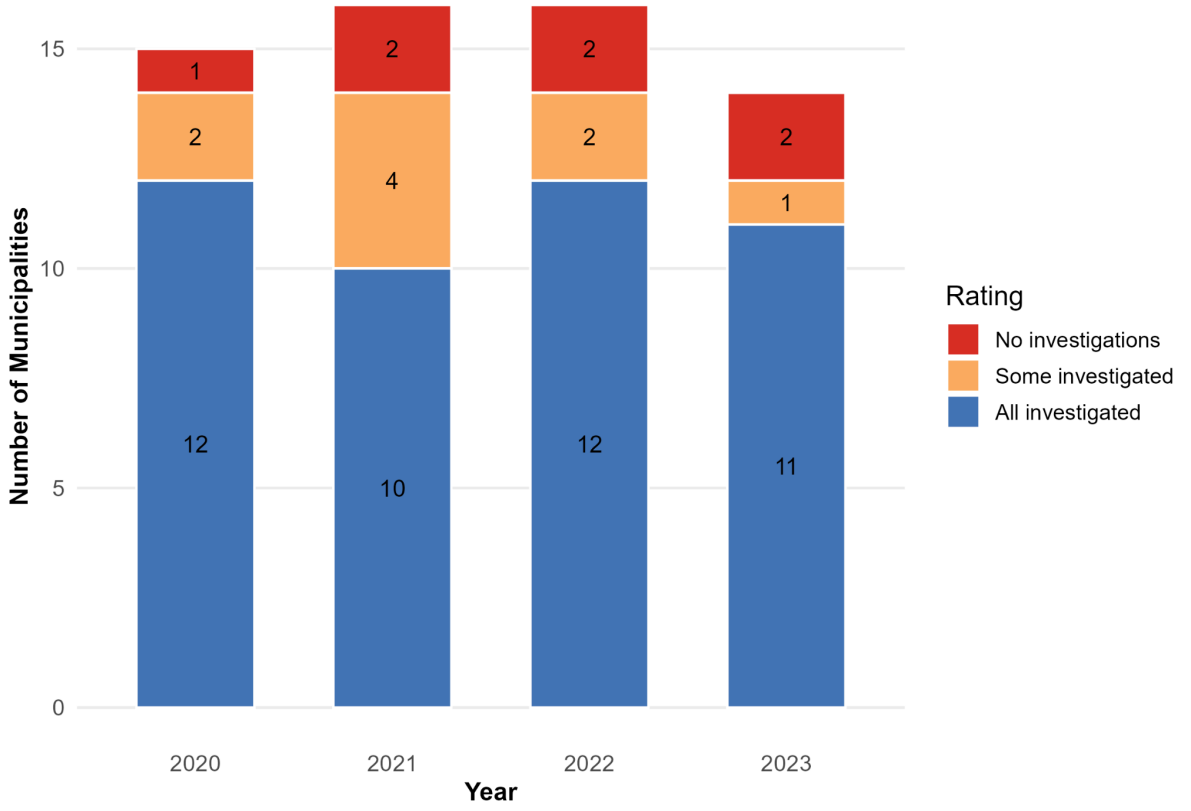



**Figure 17. Qualitative Analysis of Responsiveness to Reported Illicit Discharges.**

## Training and Education Programs (Illicit Discharge and Spill Response)

Municipal staff training demonstrated improvement over the analyzed period. Coverage for illicit discharge detection increased from 66% of municipalities in 2020 to 83% in both 2022 and 2023, while spill response training rose from 69% at baseline to 77% by 2022 and 2023.

Training represents a capacity-building investment that strengthens program performance across multiple compliance categories. Well-trained field staff are more likely to recognize early signs of illicit discharge, respond appropriately to spills, document incidents accurately, and initiate corrective actions without delay. In this sense, training functions as a multiplier: improvements in staff preparedness can enhance responsiveness in both proactive inspection programs and reactive complaint investigations.

In 2022, six municipalities did not report conducting illicit discharge detection training (**Figure 18**): Aventura, Bay Harbor Islands, Homestead, Miami Springs, the Miami-Dade Expressway Authority, and Sunny Isles Beach.

In 2023, six municipalities again did not conduct illicit discharge training, though the list shifted slightly: Bay Harbor Islands, Miami Springs, Opa-locka, Palmetto Bay, Surfside, and Virginia Gardens.

Spill prevention training showed similar gaps. In 2022, eight municipalities did not report conducting spill prevention training (**Figure 19**), the same jurisdictions that did not conduct illicit discharge training that year, along with Surfside and West Miami. In 2023, the municipalities that did not conduct illicit discharge training also did not conduct spill prevention training, with the addition of Bal Harbour and Indian Creek.

These recurring gaps indicate that while countywide training coverage has improved overall, certain municipalities continue to lack consistent annual training programs, creating uneven preparedness across jurisdictions.

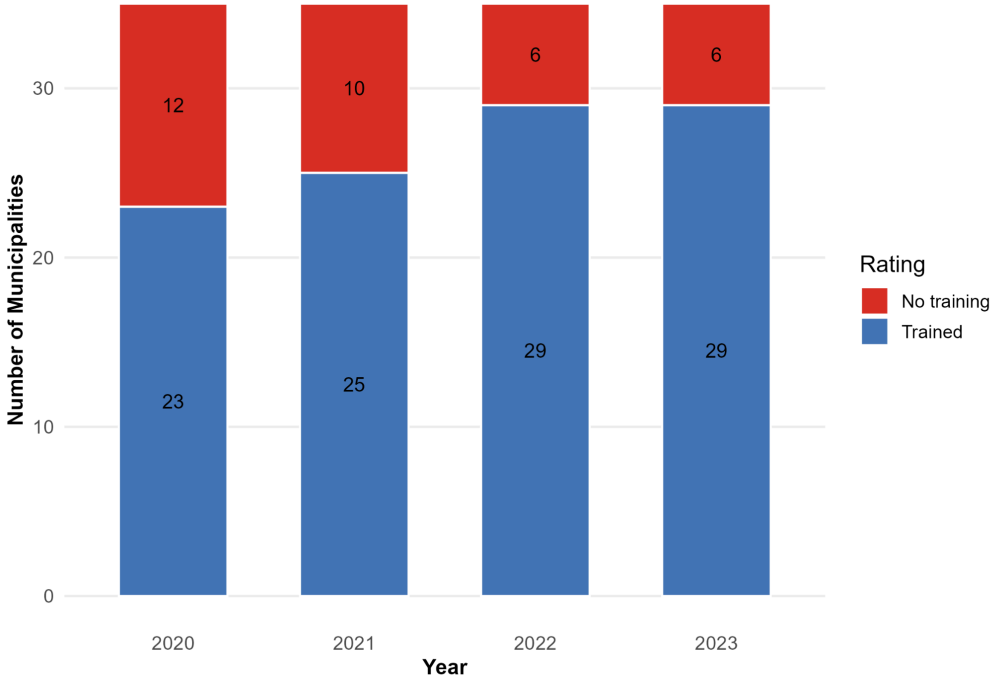



**Figure 18. Staff Training on Illicit Discharge Detection.**

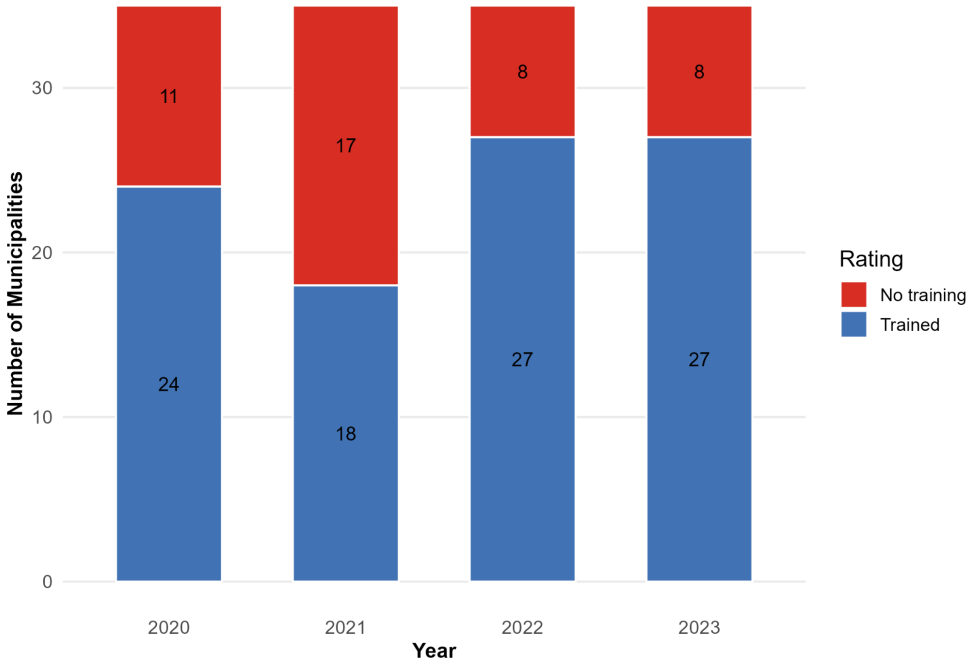



**Figure 19. Staff Training on Spill Response.**

## Public Education Programs

Public education programs had a relatively high compliance rate of 84.4% by the end of the analyzed period.

However, qualitatively, the breadth, depth, and strategic design of these programs varied considerably. We assessed not only whether outreach occurred, but also the diversity and engagement level of the strategies employed. While twelve municipalities relied primarily on static materials, such as brochures, website postings, or occasional social media messaging, almost half implemented interactive programming that actively engaged residents through school partnerships, workshops, or public events (**Figure 20**).

This distinction is significant. Passive dissemination of information fulfills outreach requirements but may have a limited behavioral impact. Effective outreach can reduce litter, improve proper fertilizer use, increase reporting of illicit discharges, and decrease illegal dumping, thereby lowering strain on infrastructure and enforcement systems.

There was also a group of municipalities that did not report conducting public education activities. By 2023 these were: Bay Harbor Islands, Miami Gardens, Miami Springs, Pinecrest and South Miami (**Figure 20**).

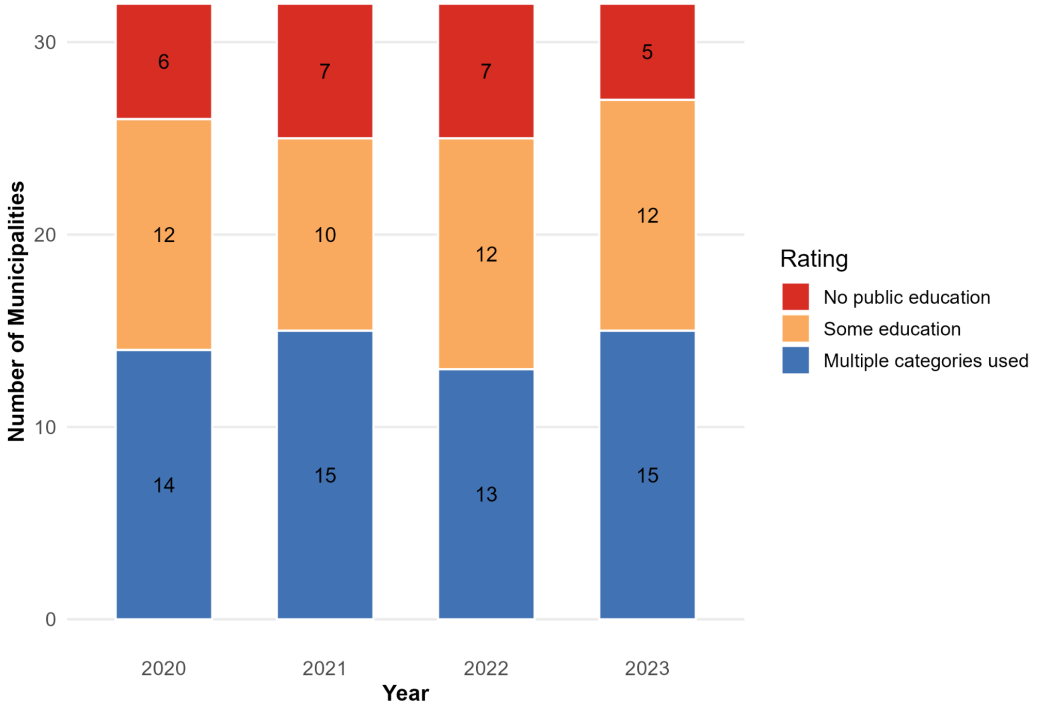



**Figure 20. Variety of Stormwater Public Education Initiatives.**

## Construction Site Inspections

Construction inspections evaluate whether sites are implementing appropriate erosion and sediment controls, properly managing materials and waste, and maintaining measures to prevent pollutants from entering the storm drain system. On average, from 2021 to 2023, 83% of the municipalities reported inspecting active construction sites to ensure that proper erosion

and sediment control practices are in place.

However, as shown in **Figure 21**, not all municipalities inspected every active site each year, leaving some construction sites uninspected and potentially increasing the risk of pollutants and construction materials entering the storm drain system. Some municipalities conducted only partial inspections or none at all.

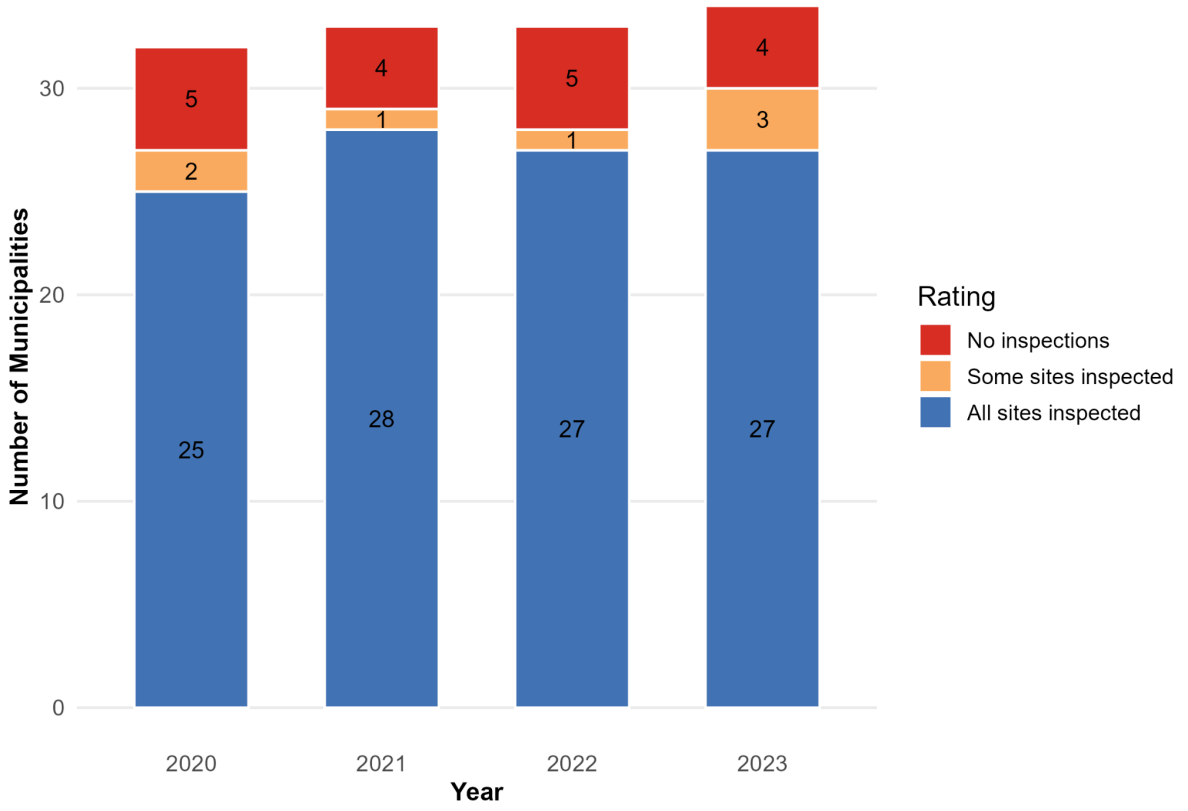



**Figure 21. Qualitative Construction Site Inspections.**

## Proposed Changes to the SWMP

A critical requirement is the need to iteratively improve Stormwater programs over the lifecycle of the permit. However, this appears to be the section with the lowest compliance rates. only a small number of municipalities proposed formal changes to their Stormwater Management Programs during this cycle. Those that did, such as City of Miami and Miami Beach, were often responding to new challenges, such as climate-driven flooding, or looking to incorporate green infrastructure practices. This proactive planning demonstrates a

commitment to adapt and enhance stormwater management beyond minimum compliance requirements.

The results demonstrate that very few municipalities are reflecting on their stormwater programs or suggesting changes, even though MS4 permits require that municipal SWMPs be regularly reviewed and updated to ensure they remain effective. **Figure 22** shows that across all years, the vast majority of municipalities fell into the category of "No reflection", meaning their annual reports did not include any indication that they evaluated the performance of their stormwater program or considered changes for improvement.[17]

Because SWMPs are the foundation of MS4 compliance, and must evolve as challenges, infrastructure, and environmental conditions change, this lack of reflection and updating represents a critical gap in stormwater management.

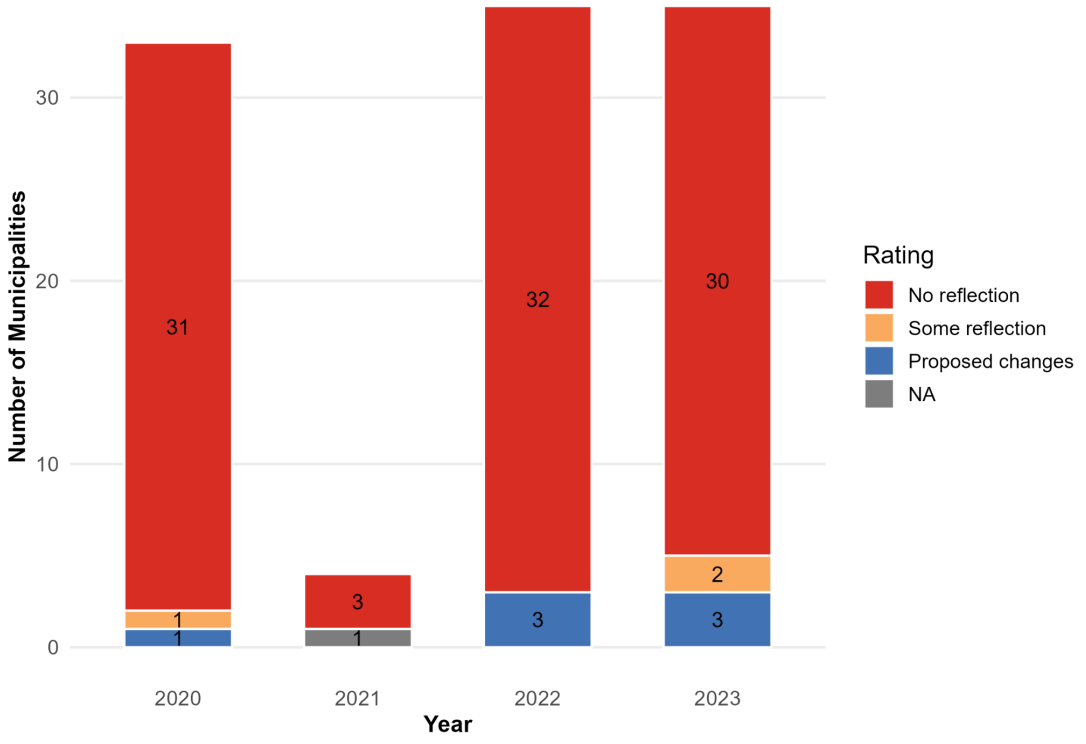



**Figure 22. Proposed iterative changes to the SWMP**

The analysis of municipal performance across categories demonstrates municipalities are making significant progress in several key areas of stormwater management, particularly in

[17] Most municipalities did not have to propose changes to their SWMP in Year 4 (2021) of the permit cycle since the MS4 permit does not require this during the 4th year of the permit cycle.

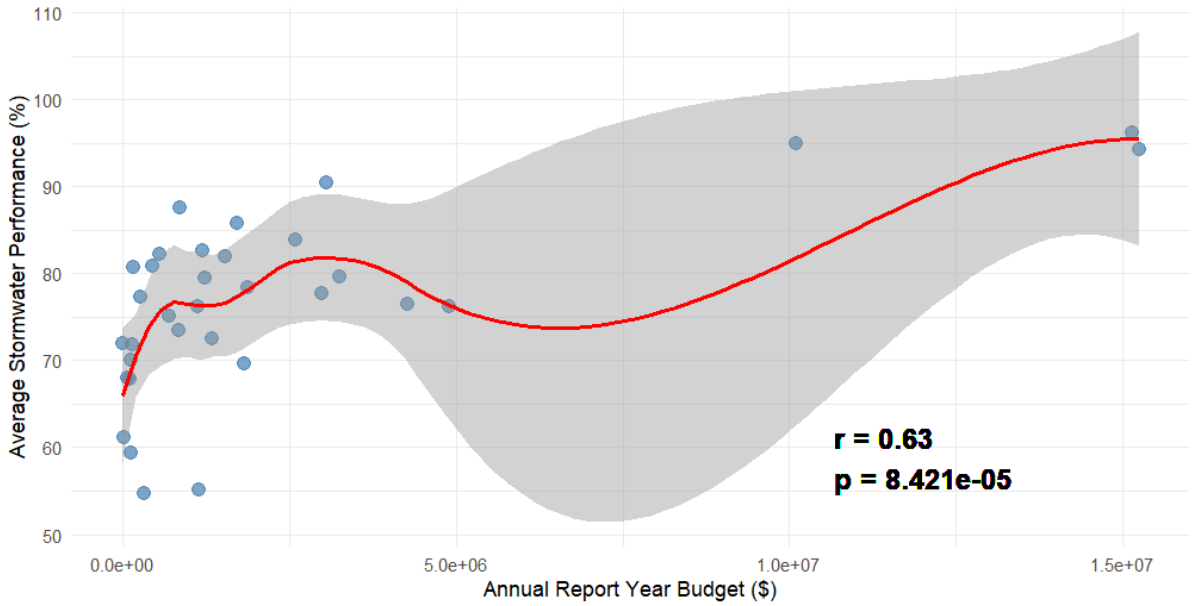
infrastructure mapping and comprehensive planning. These improvements are encouraging because they support better decision-making and more effective pollution prevention in the long term.

However, several areas, like routine inspections, proactive illicit discharge detection, and broader public education programs, have not shown substantial improvement over time. These gaps highlight opportunities for targeted support, community engagement, and capacity building to ensure that all municipalities meet the high standard of stormwater management needed to protect Biscayne Bay.

In the next section we look beyond compliance rates and attempt to analyze how different factors, such as stormwater budget, social vulnerability and outreach efforts impact the compliance rates.

# 7. Budget and Stormwater Performance

A key finding of this report is that municipalities with higher investment in stormwater management tend to achieve better overall compliance. When we compared each municipality's stormwater compliance scores with its annual stormwater budget,[18] a clear pattern emerged: municipalities that dedicate more funding to stormwater programs tend to achieve higher compliance scores.




[18] Based on the total budget figures reported by each municipality in their annual stormwater reports.

**Figure 23. Relationship Between Municipal Stormwater Budgets and Compliance Performance.**

There was a positive correlation between annual stormwater budgets and overall MS4 compliance scores. Municipalities with larger stormwater budgets generally achieved higher compliance performance, while those with smaller budgets more frequently recorded lower scores.

This suggests that adequate and sustained funding likely supports the staffing, inspection frequency, documentation systems, and maintenance activities necessary to meet permit requirements. In practical terms, financial capacity has a direct impact on compliance. Ensuring sufficient stormwater funding is directly connected to a municipality's ability to reduce flooding risk, maintain infrastructure integrity, and limit pollutant discharges to receiving waters.

# 8. Social Vulnerability and Stormwater Compliance

To understand how social factors relate to stormwater compliance, we examined the relationship between the Social Vulnerability Index (SVI) of different municipalities and their corresponding stormwater compliance scores. The SVI, developed by the Centers for Disease Control (CDC), measures community resilience to environmental hazards based on social and economic characteristics.[19] In the SVI Interactive Map, the CDC classifies data into quartiles (0 to 0.25, 0.25 to 0.50, 0.50 to 0.75, and 0.75 to 1.0), from least to most vulnerable. While there are no statistically significant cutoffs for working with SVI data, as the SVI data are relative rankings scored from 0 to 1, categorizing SVI values using a quartile classification is a common

[19]The Social Vulnerability Index (SVI) was calculated following the CDC/Agency for Toxic Substances and Disease Registry (ATSDR) methodology (Flanagan et al., 2018), using the American Community Survey from 2019 to 2023. This approach ranks census tracts based on 15 social factors grouped into four themes: Socioeconomic Status, Household Composition & Disability, Minority Status & Language, Housing Type & Transportation. Using stormwater-related data filtered for quantitative metrics and excluding data from 2020, the 15 SVI indicators were first converted into percentile ranks across all geographic units, replicating the CDC's percentile ranking method for individual variables (EPL variables). The percentile ranks within each theme were summed to generate raw theme scores (SPL variables). These theme sums were then ranked again to produce theme-specific percentile scores (RPL variables). Finally, an overall raw SVI score was calculated by summing the four theme sums and percentile ranked to derive a composite percentile rank, representing overall social vulnerability.

approach;[20] therefore, we considered the most vulnerable municipalities as those located in the 4th quartile, with an index ranging from 0.75 to 1.

Our analysis revealed that five municipalities with moderate to poor compliance scores, ranging from 78 to 55 in average compliance, also had a high vulnerability index. These included Miami Gardens, North Miami, North Miami Beach, Opa-Locka, and Hialeah. While not all low-scoring municipalities exhibited high overall vulnerability, the overlap between high SVI and low compliance is noteworthy. Addressing stormwater challenges in these communities could be key to improving performance across the County. We also observed outliers, with low vulnerability that still showed medium to low compliance scores (65 to 75 %), Pinecrest and Palmetto Bay, respectively. This demonstrates that while social vulnerability might be an aspect to consider in explaining low compliance, not all jurisdictions can attribute their lack of compliance to social conditions.

[20] Centers for Disease Control and Prevention (CDC). (2024, July 22). *SVI Frequently Asked Questions (FAQs)*. Agency for Toxic Substances and Disease Registry. Retrieved from: https://www.atsdr.cdc.gov/place-health/php/svi/svi-frequently-asked-questions-faqs.html

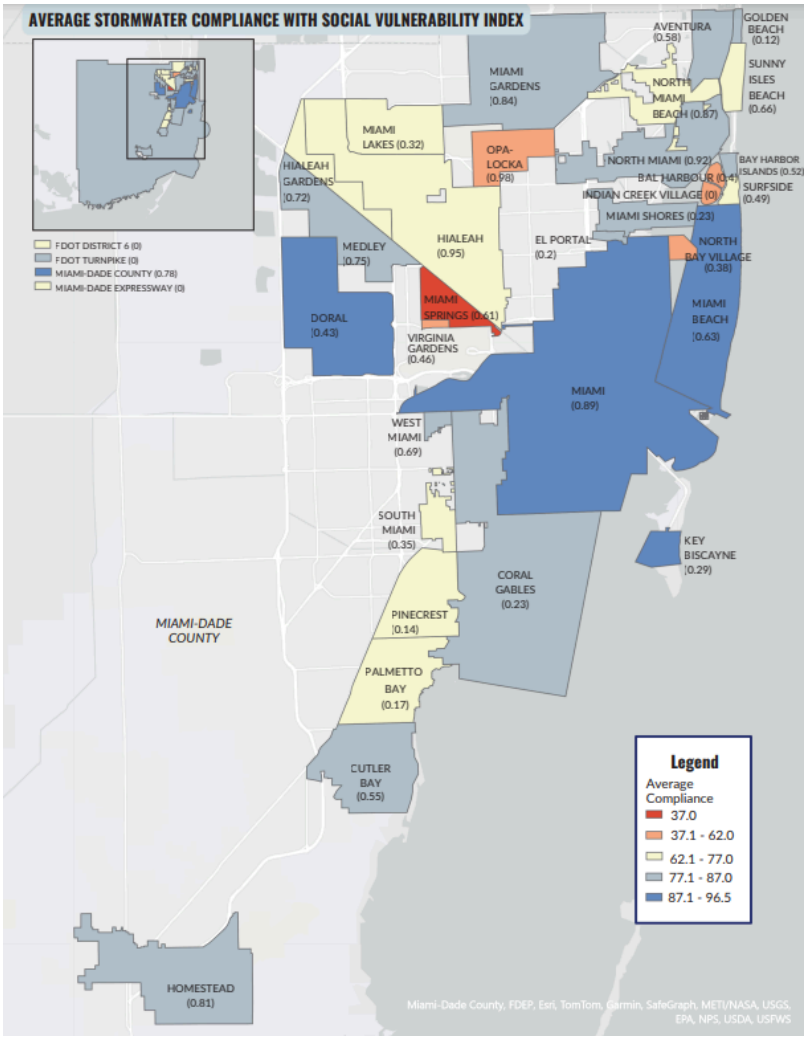



**Figure 24. Relationship Between Social Vulnerability Index (SVI) and Municipal Stormwater Compliance.**

The SVI is composed of four themes:

1. Socioeconomic status – poverty, unemployment, per capita income.

2. Household characteristics – elderly or young children, prevalence of disability, and single-parent households.

3. Housing and transportation – crowded housing, multi-unit structures, vehicle access.

4. Minority status and language barriers – non-English speakers, racial/ethnic minority populations.

When we analyzed compliance against these themes, we found that municipalities with higher shares of non-English-speaking households or minority populations tended to have moderately lower performance. A more detailed regression analysis of individual SVI components revealed that specific poverty-related and access barriers were strongly associated with lower scores. Municipalities with higher percentages of residents lacking a high school diploma, vehicle access, health insurance, or experiencing high unemployment consistently scored lower. These factors can reduce municipal revenues, limit technical capacity, and hinder community engagement in stormwater programs.[21]

Overall, the findings highlight that stormwater compliance correlated with the economic capacity of a municipality. The findings also demonstrate that specific aspects of a community's social vulnerability are most strongly correlated with lower municipal compliance. Municipalities with larger budgets and populations showed higher compliance rates, indicating that greater financial and administrative capacity supports stronger stormwater program performance. In contrast, areas with lower educational attainment and limited vehicle access exhibited lower compliance, suggesting resource and mobility barriers. While language and other vulnerability factors were not statistically significant in the final model, they may still influence local implementation capacity and should be considered in broader resilience planning.

[21] A multiple linear regression model examined factors associated with 2023 municipal compliance rates. The final model was statistically significant ($F(11,17) = 4.98$, $p = 0.0017$) and explained approximately 61% of the variance in compliance (adjusted $R^2 = 0.61$).

Higher annual report year budget ($\beta = 2.94 \times 10^{-6}$, $p < 0.001$) and population size ($\beta = 1.57 \times 10^{-5}$, $p = 0.0027$) were both positively associated with compliance, indicating that municipalities with greater financial and administrative resources achieved higher performance.

Conversely, lower educational attainment (percent without a high school diploma; $\beta = -2.69$, $p = 0.010$) and limited mobility (households without a vehicle; $\beta = -1.72$, $p = 0.039$) were negatively associated with compliance.

Other significant predictors included single-parent households ($\beta = 2.33$, $p = 0.037$), mobile homes ($\beta = 0.70$, $p = 0.012$), and crowding ($\beta = 3.13$, $p = 0.006$), which may reflect social and housing-related factors influencing local implementation.

Variables such as unemployment, no health insurance, and limited English proficiency were not retained in the final model, suggesting weaker or nonsignificant relationships after accounting for other factors.

# 9. Outreach and Stormwater Compliance Over Time

To better understand how direct engagement influences municipal performance, we examined the change in average compliance scores for municipalities that received targeted outreach following the publication of the 2022 Stormwater Compliance Report. Outreach activities included follow-up communications, provision of information on permit requirements, and opportunities for clarifying compliance expectations. Following the release of the first stormwater report, we reached out to all municipalities; however, we only met with a subset to discuss their scores and explore paths toward improved compliance. The following municipalities participated in those meetings:

- El Portal
- Pinecrest
- Palmetto Bay
- Miami-Dade County
- City of Miami
- North Bay Village
- Opa Locka
- Sunny Isles Beach
- West Miami

Municipalities that participated in outreach activities showed higher mean improvements of +10.6 percentage points, compared to those without follow-up meetings, which improved a mean of +3.9 points.[22] The observed pattern suggests that engagement and follow-up communication could contribute to positive compliance trends over time. In some cases, outreach efforts helped municipalities transition from “Low” or “Moderate” compliance categories to the “Good” range.

[22] The Wilcoxon rank-sum test was not statistically significant (p = 0.12)

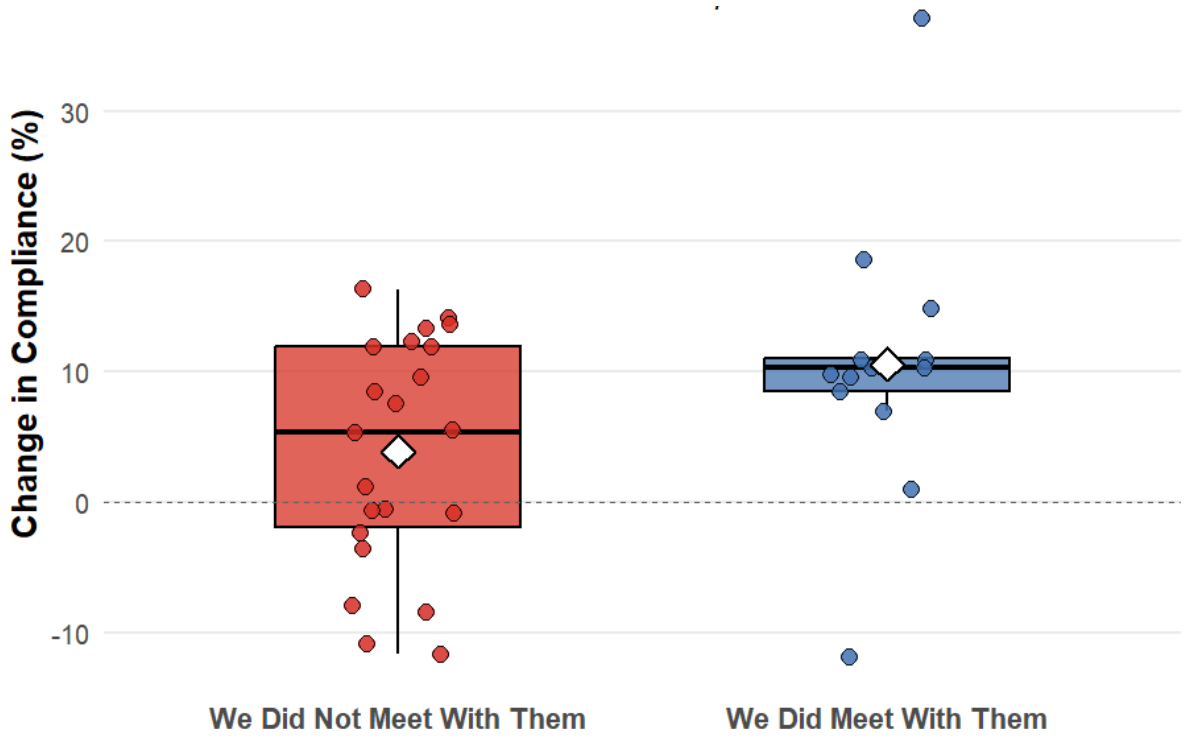



**Figure 25. Change in municipal compliance percentages between the baseline year (2020) and the post-baseline period (2021–2023), grouped by whether municipalities accepted to meet following the 2022 Stormwater report.**[23]

The most significant improvements were seen from El Portal and West Miami. El Portal has a 33.5 percentage point increase in compliance from 2020 to the analyzed period, which ranged from 2021 to 2023. West Miami was another municipality with an 18.5 point increase in compliance in comparison to the baseline.[24] These municipalities have improved in categories such as updating their SWMP, implementing litter control programs, street sweeping, proactive illicit discharge detection and training staff on spills.

This suggests that proactive engagement, particularly for underperforming municipalities, can have a measurable effect on compliance outcomes. Outreach can help address knowledge gaps

[23] Each point represents an individual municipality. Boxplots display the median (center line) and interquartile range.
[24] These improvement figures reflect the difference between each municipality's compliance score in the 2020 baseline year and their average combined compliance score across permit Years 4–6 (2021–2023). For each municipality, an overall compliance score was calculated annually by averaging the quantitative and qualitative rubric scores, expressed as a percentage. The baseline score from 2020 was then subtracted from the average of the three subsequent years (2021, 2022, and 2023) to produce a single percentage point change figure.

and administrative challenges, particularly in municipalities with limited staffing or resources for stormwater management.

These findings reinforce the importance of continued, targeted outreach as part of countywide stormwater improvement strategies.

# 10. Key Takeaways

## Significant Improvements in Mapping and SWMP

During Permit Years 4–6 (2021–2023), some municipalities made measurable progress in strengthening aspects of their planning and documentation backbone of their MS4 programs. The share of municipalities with current Stormwater Management Programs (SWMPs) increased from 54.5% in 2020 to 77.1%, and completion of stormwater outfall mapping rose from 57.1% to 88.6%. These gains are significant [25]: accurate infrastructure maps and updated SWMPs are foundational compliance tools that enable municipalities to schedule inspections, track maintenance, prioritize capital improvements, and document pollutant reduction strategies systematically. However, a measured improvement in digitizing maps and utilizing stormwater asset management tools will improve overall stormwater compliance.

In September 2022, Miami-Dade County's Board of County Commissioners unanimously approved Resolution R-838-22, which seeks to strengthen the county's stormwater regulation.[26] This resolution followed the publishing of our 2022 Stormwater Report, which included a recommendation to adopting a standard, computerized stormwater management system. This resolution urges Miami-Dade County to expand the Asset Management System (AMS) to include stormwater infrastructure. This mandate would allow the County to keep track in real time how well municipal stormwater systems are performing by monitoring critical stormwater infrastructure. A fully operational SAMS would allow for real-time or near-real-time monitoring of critical assets, including pumps, pollution control structures, pipes, and outfalls, while standardizing inspection schedules, maintenance logs, and corrective actions across jurisdictions. To this day there is no evidence that this SAMS has been fully implemented by the County.

Given that inspection-related categories (e.g., pumps, pollution control boxes, and outfalls) showed stagnation or regression during the analyzed period, full implementation of a SAMS should be treated by the County as a near-term operational priority. By translating recent

[25] Stormwater mapping showed a highly significant difference across years ($p < 0.00001$) and completing SWMP also showed significant improvement ($p = 0.0413$).
[26] Miami-Dade County, Fla., Res. No. R-838-22 (September, 2022).

planning gains into structured, technology-enabled implementation, Miami-Dade County can close the gap between documentation and on-the-ground performance.

## Compliance Gaps in Inspection-Specific Program Elements

Despite progress in mapping and documentation, routine operational compliance, particularly inspections of pipes, culverts, catch basins, pollution control structures, outfalls, and stormwater pumps, has not demonstrated sustained improvement and, in several categories, has declined relative to the 2020 baseline. These inspection programs are not administrative formalities; they are the core preventive mechanisms of an MS4 system. Without systematic field verification, municipalities cannot reliably detect preventable issues before they trigger flooding events or pollutant releases to receiving waters.

Stormwater pump inspections illustrate this regression. Compliance among municipalities with pump infrastructure declined from 94.1% in 2020 to 78.9% in 2023. Pollution control box inspections showed one of the lowest-performing trends overall, with compliance decreasing from 53.3% in 2020 to 41.2% in 2023. Pipes and culverts inspection rates declined nearly 8 percentage points compared to baseline.

The cumulative implication is significant. Mapping and SWMP documentation improvements have strengthened planning frameworks, but without consistent field-based inspections, these advances do not automatically translate into environmental protection or flood resilience.

## Targeted Outreach and Capacity Building

The findings of this report indicate that individualized outreach by the authors of the first Stormwater compliance report  is a driver of improved MS4 compliance. Municipalities that decided to engage in direct outreach following the 2022 Stormwater Compliance Report improved their average compliance scores by +10.6 percentage points, compared to +3.9 points among municipalities that decided not to participate in the outreach process.

The outreach model employed, consisting of follow-up communications, clarification of permit requirements, and opportunities for direct dialogue, could have functioned as a form of technical assistance. This pattern demonstrates that compliance gaps may not be solely the result of unwillingness but often stem from documentation challenges, limited staffing capacity, or uncertainty regarding permit interpretation.

Given these results, Miami-Dade County and the Florida Department of Environmental Protection (FDEP) should formally integrate technical assistance and capacity-building initiatives into the MS4 oversight framework. Establishing a coordinated technical assistance program, particularly targeted toward municipalities with lower compliance scores, could strengthen overall compliance with the MS4 permit.

FDEP must also strengthen its enforcement posture to ensure that chronic underperformance is met with meaningful consequences. While technical assistance and funding incentives are important tools for building capacity, they are insufficient on their own when municipalities repeatedly fail to meet basic permit requirements. FDEP should conduct periodic compliance audits, issue formal notices of violation where warranted, and require corrective action plans with enforceable timelines for municipalities that consistently fall short on inspections, reporting, or attachment submissions. Transparent public reporting of enforcement actions would further reinforce accountability and signal to all permittees that compliance is not optional. Without a credible enforcement backstop, voluntary improvement efforts risk remaining uneven and insufficient to achieve the water quality outcomes Biscayne Bay requires.

## Resource Allocation Matters

The statistical analysis confirms a meaningful association between stormwater funding levels and compliance outcomes. Municipalities with higher annual stormwater budgets consistently achieved stronger scores, while lower-resourced jurisdictions were disproportionately represented in the Low and Poor compliance categories.

High-performing municipalities such as Doral, Key Biscayne, Miami Beach, Coral Gables, and the City of Miami generally maintain comparatively larger stormwater budgets and more robust administrative capacity. While funding alone does not guarantee compliance, as demonstrated by the Village of Pinecrest and Palmetto Bay, the data demonstrate that adequate and stable investment materially improves a municipality's ability to conduct inspections, maintain infrastructure, document activities, and implement proactive programs.

This presents a structural challenge for smaller municipalities. Regional collaboration models such as interlocal agreements for specialized services, or centralized County technical support, could mitigate capacity constraints. Miami-Dade County and FDEP could play a coordinating role by expanding technical assistance programs or creating funding incentives tied to measurable compliance improvements. Aligning grant allocations or capital assistance with

MS4 performance metrics would further reinforce accountability while addressing resource inequities.

## Training and Staff Development

Training trends show moderate improvement, particularly in illicit discharge detection and spill response preparedness. Coverage for illicit discharge detection increased from 66% of municipalities in 2020 to 83% by 2022–2023. Spill response training also rose during the same period.

However, recurring gaps remain. In 2023, municipalities, including Bay Harbor Islands, Miami Springs, Opa-locka, Palmetto Bay, Surfside, and Virginia Gardens, did not report conducting any illicit discharge detection training. Similar patterns were observed in spill response instruction. These repeated omissions signal uneven institutionalization of annual training programs.

Well-trained staff are more likely to identify early warning signs of structural failure, recognize illicit connections, properly document inspections, and initiate corrective action without delay.

## Social Vulnerability Index Considerations

The analysis of Social Vulnerability Index (SVI) indicators reveals important equity dimensions in stormwater compliance. Municipalities with higher vulnerability scores, such as Miami Gardens, North Miami, Opa-locka, and Hialeah, tended to show moderate to lower compliance performance.

These factors may influence municipal revenue capacity, administrative staffing levels, and the effectiveness of public engagement strategies. In communities with limited vehicle access or higher percentages of non-English-speaking households, traditional outreach methods (e.g., centralized public meetings or English-only web postings) may not effectively reach residents.

Municipalities in high-SVI quartiles should receive targeted technical assistance, translation support, and community-based engagement tools. Community-centered compliance strategies ensure that stormwater management improvements do not disproportionately lag in vulnerable communities, where flooding and pollution impacts may already be more severe.

# 11. Recommendations for Improving Stormwater Management and MS4 Permit Compliance

## For Municipalities and Miami-Dade County:

**1. Strengthen Routine Inspections and Documentation**

Inspection-related categories, including pumps, pollution control boxes, outfalls, and subsurface conveyance systems, remain the most persistent area of underperformance. Municipalities should:

- Meet or exceed MS4 minimum inspection frequencies
- Adopt standardized inspection protocols and maintenance logs tied to corrective action timelines.
- Track inspection completion rates in real time, flagging missed inspections automatically.
- Miami-Dade County needs to expand its Asset Management System to include stormwater and share such a tool with municipalities. This will reduce documentation gaps and convert planning advances into measurable operational control.

**Enhance Illicit Discharge Detection and Elimination (IDDE)**

Proactive illicit discharge programs remain largely static. Municipalities should:

- Develop risk-based inspection schedules targeting commercial corridors, aging infrastructure, and previously identified hotspots.
- Establish or strengthen public reporting platforms.
- Train field crews to identify indicators of illicit discharge during routine work.

**Expand and Localize Public Education to Address Social Vulnerability**

Given the documented relationship between Social Vulnerability Index indicators and compliance performance, outreach must be tailored to the community context:

- In municipalities with limited vehicle access, conduct neighborhood-based workshops and mobile engagement events.

- In communities with high percentages of non-English-speaking households, provide multilingual and culturally appropriate materials.
- Transition from passive communication (brochures and websites) to interactive programming such as school partnerships, demonstrations, and community cleanups.

Public engagement is a compliance tool and can contribute to aspects such as reducing illegal dumping, fertilizer misuse, picking up pet waste, and properly disposing of hazardous materials.

## For Miami-Dade County and the Florida Department of Environmental Protection (FDEP):

**Link Funding and Institutional Support to Measurable Outcomes**

Budget size is a statistically significant predictor of compliance performance. To address disparities, funding should reinforce accountability and incentivize measurable performance improvements by:

- Prioritize technical and financial assistance for municipalities with persistent low inspection performance.
- Tie grant awards or capital allocations to documented improvements in MS4 compliance scores.
- Align stormwater investments with watershed-scale strategies, including the Reasonable Assurance Plan.

**Institutionalize Training and Capacity Building**

Training improvements are positive but uneven. To ensure consistency:

- Develop standardized curricula accessible to all permittees.
- Facilitate cross-municipal peer exchanges led by high-performing jurisdictions.
- Integrate climate resilience, extreme rainfall response, and sea-level rise considerations into technical instruction.

**Formalize Targeted Outreach**

Municipalities that received direct outreach improved compliance more substantially than those that did not. Therefore, the County and FDEP could:

- Institutionalize annual compliance briefings.

- Conduct pre–annual report submission technical check-ins.
- Prioritize outreach to municipalities with repeated inspection deficiencies.
- Frame outreach as structured technical assistance, distinct from enforcement.

### For the Florida Department of Environmental Protection (FDEP):

**Strengthen Permit Renewal, Oversight, and Enforcement**

- Renew MS4 permits promptly at the end of each five-year cycle.
- Conduct periodic compliance audits and require corrective action plans with enforceable timelines for municipalities failing to meet inspection requirements.
- Apply escalating enforcement mechanisms where persistent noncompliance is detected.

# 12. Conclusion

The findings of this updated assessment indicate that municipalities throughout Miami-Dade County have achieved notable gains relative to the 2020 baseline, specifically regarding infrastructure mapping, reporting completeness, and the adoption of Stormwater Management Programs. However, a significant disconnect between administrative planning and on-the-ground execution remains: routine field inspections of critical infrastructure have stagnated or decreased, and compliance levels vary widely between jurisdictions. Municipalities with larger annual budgets and robust administrative frameworks consistently achieved higher scores that those with lower budgets. Correlations with social vulnerability indicators also suggest that local socioeconomic barriers materially impact a municipality's capacity to fulfill permit obligations. Notably, municipalities that participated in targeted outreach following the 2022 Stormwater Compliance Report recorded more substantial improvements, highlighting that technical assistance and direct engagement are effective drivers of progress, especially for low scoring municipalities.

These results are significant because effective stormwater management is fundamentally linked to the health of Biscayne Bay. Irregular inspection schedules, documentation gaps, and administrative delays in permit renewals contribute directly to nutrient pollution, seagrass loss, and the overall degradation of one of our region's most valuable natural assets. With the increasing pressures of climate change, including extreme rainfall and sea-level rise, the environmental risks of uneven compliance will only intensify. Closing the existing gap between documentation and implementation, by strengthening inspection regimes, expanding digital asset management, ensuring rigorous FDEP oversight and enforcement, and securing stable

funding, is necessary to ensure that every municipality fulfills its role in preserving Biscayne Bay for the long term.

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# Annex I

## Rubric

| Category | Quantitative Compliance | Qualitative Compliance |
|---|---|---|
| Written Stormwater Management Program (SWMP) | 0 - No SWMP<br>1 - Complete SWMP | 0 - No SWMP<br>2 - SWMP is 11+ years old<br>3 - SWMP is 6-10 years old<br>4 - SWMP is 0-5 years old |
| Annual reports submitted (Yr 4,5,6) | 0 - No Annual Report submitted<br>1 - Complete Annual Report submitted | 0 - No Annual Report submitted<br>1 - Incorrect form or missing information<br>2 - Complete Annual Report submitted |
| Water Quality Monitoring Program Outside of Basic DERM Program | NA - Not required in the permit for municipalities | 0 - No water quality monitoring<br>1 - Sporadic or infrequent water quality monitoring performed<br>2 - Frequent water quality monitoring performed |
| Submitted Required Annual Report Attachments | 0 - No attachments/incomplete attachments<br>1 - All attachments are submitted | 0 - No attachments<br>1 - Incomplete attachments<br>2 - All attachments are submitted |
| Map of the stormwater system and outfalls* | 0 - No stormwater or outfalls map 1 - There are stormwater and outfall maps | 0 - No stormwater or outfalls map<br>1 - Incomplete or out-of-date map<br>2 - Complete and current map |
| Conduct inspection for at least 33% of structural controls (dry retention, exfiltration trenches, french drains, | 0 - 33% inspection not met<br>1 - 33% inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (< 33%)<br>2 - Complete inspection met (33% >) |

| | | |
|---|---|---|
| grass treatment, swales, wet detention) | | |
| Conduct quarterly inspection of pollution control boxes | 0 - Quarterly inspection not met<br>1 - Quarterly inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (< quarterly)<br>2 - Complete inspection met (quarterly >) |
| Conduct semi-annual inspection of stormwater pumps | 0 - Semi-annual inspection not met<br>1 - Semi-annual inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (< semi-annual)<br>2 - Complete inspection met (semi-annual >) |
| Conduct annual inspection of major stormwater outfalls | 0 - Annual inspection not met<br>1 - Annual inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (at least one inspection for some outfalls, but not all)<br>2 - Complete inspection met (at least one inspection per major outfall) |
| Conduct an inspection for at least 10% of pipes and culverts | 0 - 10% inspection not met<br>1 - 10% inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (<10%)<br>2 - Complete inspection met (10% >) |
| Conduct an inspection of at least 10% of storm sewer inlets, catch basin grates, ditches, and conveyances | 0 - 10% inspection not met<br>1 - 10% inspection met | NA - Not applicable<br>0 - No inspection<br>1 - Partial inspection (<10%)<br>2 - Complete inspection met (10% >) |
| Implementation of a litter control program for public streets, roads, and highways in the Permittees' | 0 - No litter control program<br>1 - There is a litter control program | 0 - No litter control program<br>1 - Monthly litter collection<br>2 - Weekly litter collection |

| | | |
|---|---|---|
| jurisdiction | | |
| Implementation of a street sweeping schedule | 0 - No street sweeping schedule<br>1 - There is a street sweeping schedule | 0 - No street sweeping schedule<br>1 - Street sweeping annually<br>2 - Street sweeping between annual and monthly<br>3 - Street sweeping monthly |
| Report on the proactive inspection program plan for identifying and eliminating sources of illicit discharges, connections, or dumping to the MS4 | 0 - No proactive inspections<br>1 - There are proactive inspections | 0 - No proactive inspections<br>1 - The County or the City is performing proactive inspections<br>2 - The City performed proactive inspections |
| Reactive investigations of reports of suspected illicit discharges match the total reports received | NA - No reports to investigate<br>0 - Fewer investigations than reports<br>1 - All reports had an investigation | NA - No reports to investigate<br>0 - No investigations<br>1 - Inspection of some reports<br>2 - All reports had an investigation |
| Personnel training/refresher for illicit discharges | 0 - No personnel were trained<br>1 - Personnel were trained | 0 - No personnel were trained<br>1 - Personnel were trained |
| Personnel training/refresher for spill prevention response | 0 - No personnel were trained<br>1 - Personnel were trained | 0 - No personnel were trained<br>1 - Personnel were trained |
| Implementation of public education programs* | 0 - No public education implemented<br>1 - Public education was implemented | 0 - No public education implemented<br>1 - Public education was implemented<br>2 - Several categories were utilized to promote public education |

| | | |
|---|---|---|
| Inspection of all active construction sites for proper stormwater, erosion, and sedimentation BMP's | 0 - No inspections of construction sites<br>1 - Inspection of all construction sites | 0 - No inspections of construction sites<br>1 - Inspection of some construction sites<br>2 - Inspection of all construction sites |
| Proposed changes to the SWMP | 0 - No proposed changes<br>1 - Proposed changes were written | 0 - No reflection<br>1 - Some reflection<br>2 - Reflection and proposed changes to the SWMP |

# Supplementary information

## Standard Deviation of Average Compliance Scores from 2021 to 2023

| Municipalities | Standard Deviation for Quantitative Compliance Average (2021-2023) | Standard Deviation for Qualitative Compliance Average (2021-2023) |
|---|---|---|
| Aventura | 13 | 6.08 |
| Bal Harbour | 3.78 | 5.29 |
| Bay Harbor Islands | 41.35 | 35.23 |
| Coral Gables | 8.182 | 3.21 |
| Cutler Bay | 2.641 | 2.51 |
| Doral | 6.35 | 5.77 |
| El Portal | 6.50 | 8.54 |
| Florida Department of Transportation District 6 | 9.71 | 2.08 |
| Florida Department of Transportation Turnpike | 6.50 | 5.50 |
| Golden Beach | 2.88 | 4.04 |
| City of Hialeah | 6.50 | 6.248 |
| Hialeah Gardens | 5.50 | 7 |
| Homestead | 0.57 | 2.51 |
| Indian Creek | 2.081 | 0.57 |
| Key Biscayne | 0.52 | 2.30 |
| Medley | 3.78 | 2.64 |
| City of Miami | 3.46 | 0.572 |
| Miami Beach | 0.57 | 0.57 |
| Miami-Dade County | 2.88 | 4.04 |
| Miami Gardens | 2.64 | 1.15 |

| | | |
|---|---|---|
| Miami-Dade Expressway | 7.54 | 5.85 |
| Miami Lakes | 35.94 | 35.55 |
| Miami Shores | 6.65 | 2.089 |
| Miami Springs | 3.053 | 2.88 |
| North Bay Village | 42.82 | 34.69 |
| North Miami | 5.77 | 3.46 |
| North Miami Beach | 14.36 | 11.01 |
| Opa-Locka | 11.06 | 8.66 |
| Palmetto Bay | 2 | 2.51 |
| Pinecrest | 3.05 | 2.30 |
| South Miami | 3.46 | 5.19 |
| Sunny Isles Beach, Florida | 8.18 | 6.24 |
| Surfside | 1.15 | 1.52 |
| Virginia Gardens | 10.14 | 8.08 |
| West Miami | 0.57 | 3.05 |

## Statistical Analysis Methods

### Comparison of Stormwater Performance Scores Across Years

To assess changes in municipal stormwater performance over time, quantitative and qualitative scores were combined to calculate a single average compliance percentage per municipality for each year. Data from 2020 and the averaged scores for the 2021–2023 period were then merged by municipality to allow direct comparisons. A paired t-test evaluated whether the overall change across municipalities was statistically significant, and differences for individual municipalities were calculated to identify improvements or declines. Side-by-side bar charts and summary statistics were used to visualize and summarize the results.

### Statistical Assessment of Rubric Trends

To evaluate changes in municipal stormwater program performance over time, we applied Fisher's Exact Test to quantitative rubrics and Kruskal–Wallis tests to qualitative rubrics. Quantitative rubrics, coded as 0 or 1, were analyzed using contingency tables to assess year-to-year differences. Qualitative rubrics, which have multiple ordered categories, were converted to numeric ranks and analyzed to test for differences across years. These tests provide an objective measure of whether observed trends are statistically distinguishable, complementing the visual trends reported in figures.

### Association Between Municipal Stormwater Performance and Annual Report Year Budget

To assess whether municipal stormwater performance was associated with financial resources, we examined the relationship between the average combined performance score (2021–2023) and the annual report year budget for each municipality. Normality of both variables was evaluated using the Shapiro–Wilk test, which indicated that budget data were not normally distributed. Accordingly, we applied a Spearman rank correlation to quantify the strength and significance of the monotonic relationship. To visualize the association, a scatterplot with a LOESS curve was generated, displaying all data points and annotated with the Spearman correlation coefficient (r) and corresponding p-value. Residuals from a simple linear model were inspected to confirm the appropriateness of a monotonic approach.

### Effect of Outreach on Municipal Stormwater Compliance

To evaluate the impact of targeted outreach on municipal stormwater performance, we calculated the change in average compliance scores for each municipality between the 2020

baseline and the 2021–2023 period. Municipalities were classified based on whether they received outreach following the 2022 Stormwater Compliance Report. A Wilcoxon rank-sum test was used to assess whether the difference in compliance change between the two groups was statistically significant, as the data did not meet normality assumptions.

**Social Vulnerability Index (SVI) Construction**

The SVI was developed following the CDC/ATSDR approach.[27] Fifteen social and demographic indicators were selected to represent four main dimensions of vulnerability: (1) socioeconomic status, (2) household composition and disability, (3) minority status and language, and (4) housing type and transportation.

All indicators were converted to percentile ranks to show each municipality's relative standing across Miami-Dade County. Within each theme, the ranked indicators were summed to produce a theme-specific score. The four theme scores were then combined to calculate an overall raw SVI value, which was subsequently converted to a percentile score representing total social vulnerability. Higher percentile values indicate greater relative vulnerability.

**Associations Between Social Vulnerability and Stormwater Compliance**

A multiple linear regression analysis was conducted to evaluate how socioeconomic and demographic factors influence municipal stormwater compliance. The dependent variable was the percentage of compliance derived from the 2023 qualitative rubric. Independent variables included municipal budget, population, and indicators related to education, employment, household structure, health insurance, housing, and mobility.

All variables were screened for completeness and converted to numeric form. A full regression model was first fitted using all predictors. Stepwise model selection based on the Akaike Information Criterion (AIC) was then applied to identify the most parsimonious model. Model performance was assessed using the adjusted $R^2$ and overall p-value, and the statistical significance of individual predictors was determined by their p-values and confidence intervals.

[27] Flanagan, B. E., Hallisey, E. J., Adams, E., & Lavery, A. (2018). Measuring Community Vulnerability to Natural and Anthropogenic Hazards: The Centers for Disease Control and Prevention's Social Vulnerability Index. *Journal of environmental health*, *80*(10).

**Statistical Analysis Results- Supplementary Tables**

**Table S1.** Kruskal–Wallis Test Results for Qualitative Scores

For qualitative metrics, Kruskal–Wallis tests revealed two rubrics with statistically significant differences: completion of Stormwater Management Programs and stormwater outfall mapping.

| Rubric (Qualitative) | $\chi^2$ (Chi-sq) | df | p-value | Interpretation |
|---|---|---|---|---|
| Annual Report Quality | 6.8112 | 3 | 0.0782 | Not significant |
| Monitoring Conducted Outside of DERM | 1.2106 | 3 | 0.7505 | Not significant |
| Annual Report Attachments Quality | 1.3036 | 3 | 0.7283 | Not significant |
| Structural Controls Inspection Quality | 1.6890 | 3 | 0.6394 | Not significant |
| Pollution Control Box Inspection Quality | 0.7459 | 3 | 0.8624 | Not significant |
| Pump Station Inspection Quality | 2.4902 | 3 | 0.4771 | Not significant |

| | | | | |
|---|---|---|---|---|
| Outfall Inspection Quality | 3.5480 | 3 | 0.3146 | Not significant |
| Pipe and Culvert Inspection Quality | 0.5987 | 3 | 0.8967 | Not significant |
| Sewer Inlet and Basin Inspection Quality | 1.3078 | 3 | 0.7273 | Not significant |
| Litter Control Practices | 0.7675 | 3 | 0.8572 | Not significant |
| Street Sweeping Practices | 0.9205 | 3 | 0.8205 | Not significant |
| Illicit Discharge Plans | 0.5146 | 3 | 0.9157 | Not significant |
| Illicit Discharge Investigations | 1.2681 | 3 | 0.7367 | Not significant |
| Staff Training on Illicit Discharge Prevention | 4.1654 | 3 | 0.2442 | Not significant |
| Spill Response Training Quality | 7.1080 | 3 | 0.0685 | Marginal (trend, not significant) |

| | | | | |
|---|---|---|---|---|
| Public Education and Outreach Programs | 0.4058 | 3 | 0.9390 | Not significant |
| Construction Runoff Control Measures | 0.4693 | 3 | 0.9256 | Not significant |
| SWMP Implementation Changes | 2.7047 | 3 | 0.4394 | Not significant |
| SWMP Document Completeness | 8.2390 | 3 | 0.0413 | Significant |
| Outfall Map Completeness and Quality | 25.8310 | 3 | <0.001 | Significant |

**Table S3.** Final linear regression model predicting municipal stormwater compliance scores. The table presents coefficient estimates, standard errors, t-values, and p-values for each predictor retained in the stepwise-selected model. Significant predictors ($p < 0.05$) indicate factors associated with higher or lower compliance scores.

| Predictor | Estimate | Std. Error | t value | p-value | Significance |
|---|---|---|---|---|---|
| Intercept | 102.5 | 13.22 | 7.75 | <0.001 | *** |
| Annual report year budget | 0.00000294 | 0.000000595 | 4.94 | 0.000125 | ** |
| Population | 0.0000157 | 0.00000448 | 3.50 | 0.0027 | ** |
| Unemployment | -1.65 | 1.275 | -1.29 | 0.213 | |
| No high school diploma | -2.692 | 0.9312 | -2.89 | 0.0102 | * |
| No health insurance | -0.7048 | 0.4409 | -1.60 | 0.128 | |
| Age 17 and younger | -0.4716 | 0.3589 | -1.31 | 0.206 | |
| Single-parent household | 2.329 | 1.029 | 2.26 | 0.0369 | * |

| | | | | | |
|---|---|---|---|---|---|
| Racial/ethnic minorities | -0.2028 | 0.1724 | -1.18 | 0.256 | |
| Mobile homes | 0.7033 | 0.2496 | 2.82 | 0.0119 | * |
| Crowding | 3.131 | 1.008 | 3.11 | 0.0064 | ** |
| No vehicle | -1.718 | 0.7682 | -2.24 | 0.0390 | * |