INTEGRATED WET WEATHER IMPROVEMENT PLAN PHASE 2

City of Lakewood, Ohio
March 1, 2019

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CHAPTER 1 – EXECUTIVE SUMMARY

This Integrated Wet Weather Improvement Plan and Report (IWWIP) has been developed by the City of Lakewood pursuant to and in fulfillment of its obligations under its National Pollutant Discharge Elimination System (NPDES) permit to develop an Integrated Plan consistent with EPA's June 2012 Municipal Stormwater and Wastewater Planning Approach Framework. The Lakewood IWWIP provides the regulatory roadmap for the best, most cost-effective environmental and public health improvement for Lakewood's compliance with the Clean Water Act (CWA).

As federal and state regulators have long acknowledged, Lakewood's circumstances are unlike other communities'. Lakewood sewers are a singular mix of intermingled sewer types that were never designed to work as a system. The city has been fully built out for about a century. Lakewood is socially and economically diverse, where affordable housing sustains large economically vulnerable households. Yet Lakewood has never wavered in delivering progress in investment in environmental and public health improvement. Lakewood sustains progress because it intends to continue its reinvention as a vibrant 21st-century city, no matter what regional trends confront it.

This document and its appendices summarize many years of intensive investigation and evaluation to determine the best measures to address improvement of Lakewood's overflows. Lakewood's unique circumstances, which require maximum flexibility to modernize its highly complex collection system and foster necessary investment on private property, do not lend themselves to typical solutions. Accordingly, this IWWIP prioritizes remedial measures based on overall reduction of pollutant discharges. The IWWIP closely examines Lakewood's unique infrastructure characteristics in the context of Lakewood's affordability challenges as viewed under standard metrics and the realities of Lakewood's unique local conditions.

Chapter 2 below details how Lakewood's history formed today's Lakewood into a fully-built out, inner-ring suburb of the City of Cleveland with a peculiar sewer "system" that, despite its idiosyncrasies, performs well. It demonstrates how Lakewood has always sustained progress in improving its system, including voluntary projects in recent years and other efforts required under Lakewood's NPDES permit. Chapter 2 also describes Lakewood's cutting-edge private property source control project and the full integration of wet-weather improvement into city codes, development and planning. All of this progress has occurred without benefit of a judicial consent decree.

Chapter 3 reviews Lakewood's demographic and financial capability, underscoring that Lakewood's below-average median household income and significant regional factors threaten Lakewood's efforts to sustain vibrancy and environmental improvement. Chapter 4 provides an overview of applicable regulations. Primary among those is the recent passage of the Water Infrastructure Improvement Act, which codified EPA's Integrated Planning Framework. The prioritization and Adaptive Management components in Lakewood's IWWIP are fully supported by the intent of Congress in its Clean Water Act amendments specifically aimed at municipalities like Lakewood. Indeed, the Integrated Planning approach is the only path forward that can sustain the pollutant reduction that will achieve the goals of the Clean Water Act.

Reports on detailed technical investigation, modeling, analyses and alternatives selection are set forth in Chapters 5 through 8. Lakewood's exemplary investigation of its complex, unique system is described in Chapter 5, as are provisions of Lakewood's extremely detailed "all-pipes" model. The level of analysis and modeling reaches to the parcel level. This is a very robust foundation for identifying which measures provide the best pollutant reduction, which is the process described in Chapter 6. Chapter 7 provides a detailed, overflow-by-overflow analysis of the various control options evaluated.

Chapter 8 provides the culmination of the alternatives analysis into a comprehensive plan of prioritized measures. The site-specific control measures were combined into systemwide solution sets. The effect of these integrated solution sets were then analyzed by continuous modeling for the typical year and set of design storms identified specifically for the city's system. Costs for each solution set were applied. The result is the list of prioritized solutions in Chapter 8.

A critical element of an Integrated Plan under the new 33 USC Section 1412(s) is to include public participation in the development of the plan. This is Element 4 of EPA's June 2012 Integrated Planning Framework. Lakewood is a city with an extremely active and engaged citizenry, where participation by highly interested and talented citizens is commonplace. The city developed its Community Vision with just such a process. This IWWIP from the beginning has benefited from the same extremely active public engagement. Chapter 9 and its extensive appendix document the intense public engagement that was essential in shaping the principles and priorities, including the priority of individual solution sets, in the final plan.

The entirety of Chapters 1-9 constitute the report section of Lakewood's submission. Chapter 10 is the actual Integrated Wet Weather Improvement Plan. This document has been ratified and endorsed by Lakewood City Council as the formal plan of the city.

Lakewood's Integrated Wet Weather Improvement Plan is precisely what Congress intended for municipalities when it passed the Water Infrastructure Improvement Act in December 2018. Local priorities are addressed in a detailed, logical, affordable path forward based on each step achieving the best environmental and public health improvement for the dollars spent.

As its very name suggests, Lakewood is fundamentally defined by its water resources (Figure 1-1). By implementing this IWWIP, the Lakewood community is excited to sustain its progress toward building a resilient 21st-century city.

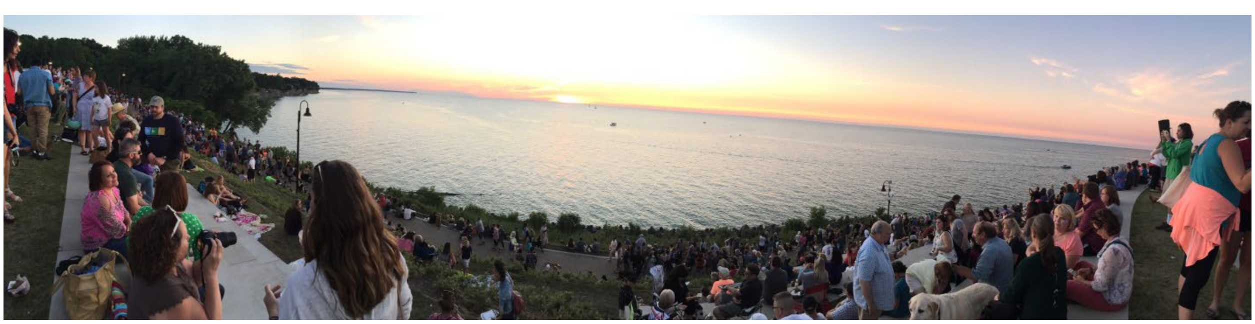


FIGURE 1-1. Residents enjoying the Summer Solstice at Lakewood Park

CHAPTER 2 – LAKEWOOD HISTORY AND PERFORMANCE OF SEWER SYSTEM

2.1 About Lakewood

Lakewood was organized in 1819 as Rockport Township. Incorporated in 1911, Lakewood began as a collection of fruit farms and orchards. Following the housing boom of the early 1920s, it became recognized as the "City of Beautiful Homes."

The City of Lakewood is a first-ring suburb located in northeast Ohio. Lakewood is bounded to the north by Lake Erie, to the west by the Rocky River, and to the east and south by the City of Cleveland. Lakewood has an area of 5.6 square miles and a population of 50,866, making it the third-largest city in Cuyahoga County and, with nearly 10,000 people per square mile, the most densely populated city in the State of Ohio.

2.1.1 Lakewood Population and Landscape Reflect History

With proximity to industry in Cleveland, Lakewood was designed and built as a streetcar community. The community's dependence on mass transit prior to World War II created today's extreme population density. Lakewood ranks 125th of 19,300 municipalities in the U.S. for population density (Figure 2-1).

Among that dense population is great demographic diversity, often termed "A Tale of Many Lakewoods." There are over 25 languages spoken at Lakewood High School. Along with ethnic diversity is a broad range of economic diversity. While Lakewood views its many different cultural dimensions as a strength, each presents challenges. Lakewood has always been an economically vulnerable community. Forty-five percent of our public school students qualify for free or reduced lunches by federal poverty standards. Thirty percent of our households are below poverty level or close. Lakewood's primary neighbor, the City of Cleveland, lags behind only Detroit in national rankings for large cities with a high percentage of low-income residents (see https://en.wikipedia.org/wiki/List_of_lowest-income_places_in_the_United_States).

Lakewood embraces its future as a vibrant 21st-century city for people in all demographics. Lakewood has the highest concentration of millennials with a college degree or higher in all of Greater Cleveland (Fifth Migration Study). Recent immigration of this generation has lowered our median age to 34—the youngest city in Cuyahoga County. Our educational attainment has improved significantly. Today, 20 percent of our residents have a two-year degree and 44 percent have a four-year degree or higher. Yet Lakewood's rebound remains fragile. The success of the community is despite a general population outflow from the northeast Ohio region and the State of Ohio, related economic realignment, and structural changes in Ohio affecting municipal finance.

50,866 residents	**17,000** structures	**5.6** square miles
3.7% Unemployment	**180** miles of sidewalks	**85** miles of sidewalk assessed and repaired since 2013
92 miles of roads	**160** miles of sewers built 1910-1930	**50%** houses built by 1920 pre-WWII community
30,000 housing units	**45%** residential units owner-occupied, **55%** rental	**15th** largest Ohio city
31% of the population in the Millennial generation	**4,300** Employers	**10th** largest workforce in Ohio with more than 29,000
$47,800 median household income	Ranked **#125** of 19,300 cities in the US for population density	**9,285** residents/sq. mile

FIGURE 2-1. Lakewood by the numbers

2.1.2 A City of Homes Requires Constant Reinvention

Lakewood's motto is "A City of Homes." The housing stock in Lakewood is the community's greatest asset. In the Great Recession beginning in 2008, Lakewood's well-kept homes are what enabled it to weather the economic storm better than most other communities in a region often cited as "ground zero" for the subprime mortgage crisis. In total, Lakewood has 30,000 housing units but Lakewood is unique in its ratio of owner-occupied dwellings to rental units. Fifty-four percent of these units are rentals. There are 19 high-rise buildings over 75 feet tall, built in the 1970s, the tallest of which is 30 stories.

Today, half of all the 17,000 structures—including residential, commercial and industrial— are 100 years or older. The rest, by and large, are 80 years old. The city has the oldest housing stock of all communities with a population over 25,000 in the State of Ohio. Specifically, over 60 percent of its 30,000 housing units were constructed prior to 1940. The city's public safety obligation includes the oversight of each and every one of these structures. Reinventing these structures for their second century is a major focus and must not be compromised. Current strategies have proven very effective in promoting Lakewood as a desirable place to invest as measured by our rebound in valuations from the Great Recession of 2008.

To sustain its future as a "City of Homes," Lakewood's municipal government has adopted the following four central goals:

- Economic Development
- Vibrant Neighborhoods
- Safe and Secure Community
- Sound Governance

Each of these goals is highly dependent upon the others. All of these goals are supported by strong community engagement reflected in the Community Vision developed by its residents.

2.2 Original Infrastructure Becomes A System of Systems

What is true of Lakewood buildings and surface infrastructure is also true of Lakewood's unique sewer "system." Lakewood's challenge is to sustain its progress by efficiently and cost-effectively updating its unique infrastructure in a densely populated city that is fully built-out.

Lakewood's "sewer system" was designed and built in uncoordinated bursts during the construction boom between 1910 and 1940. More accurately, Lakewood could say today it has something of a "system of systems." For example, Forest Cliff Avenue had a filter bed constructed on the cliff that discharged directly into Lake Erie (Figure 2-2). The primary purpose of this original infrastructure was the protection of public health against threats like typhoid, diphtheria, and tuberculosis by simply moving waste to discharges in water bodies without any central treatment facility.

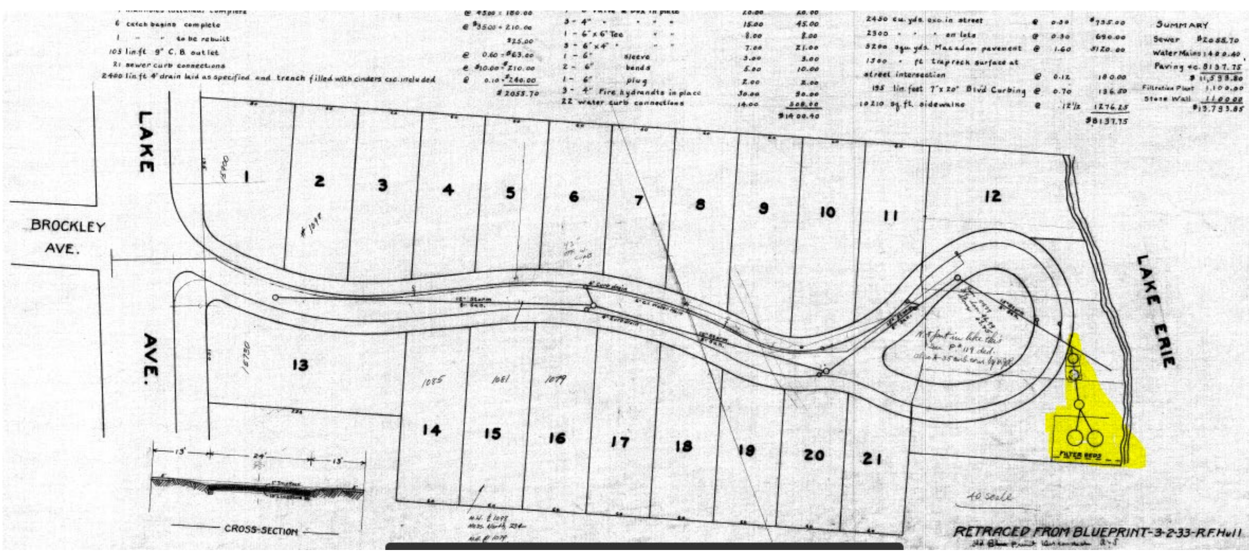


FIGURE 2-2. Forest Cliff filter bed plan, 1933

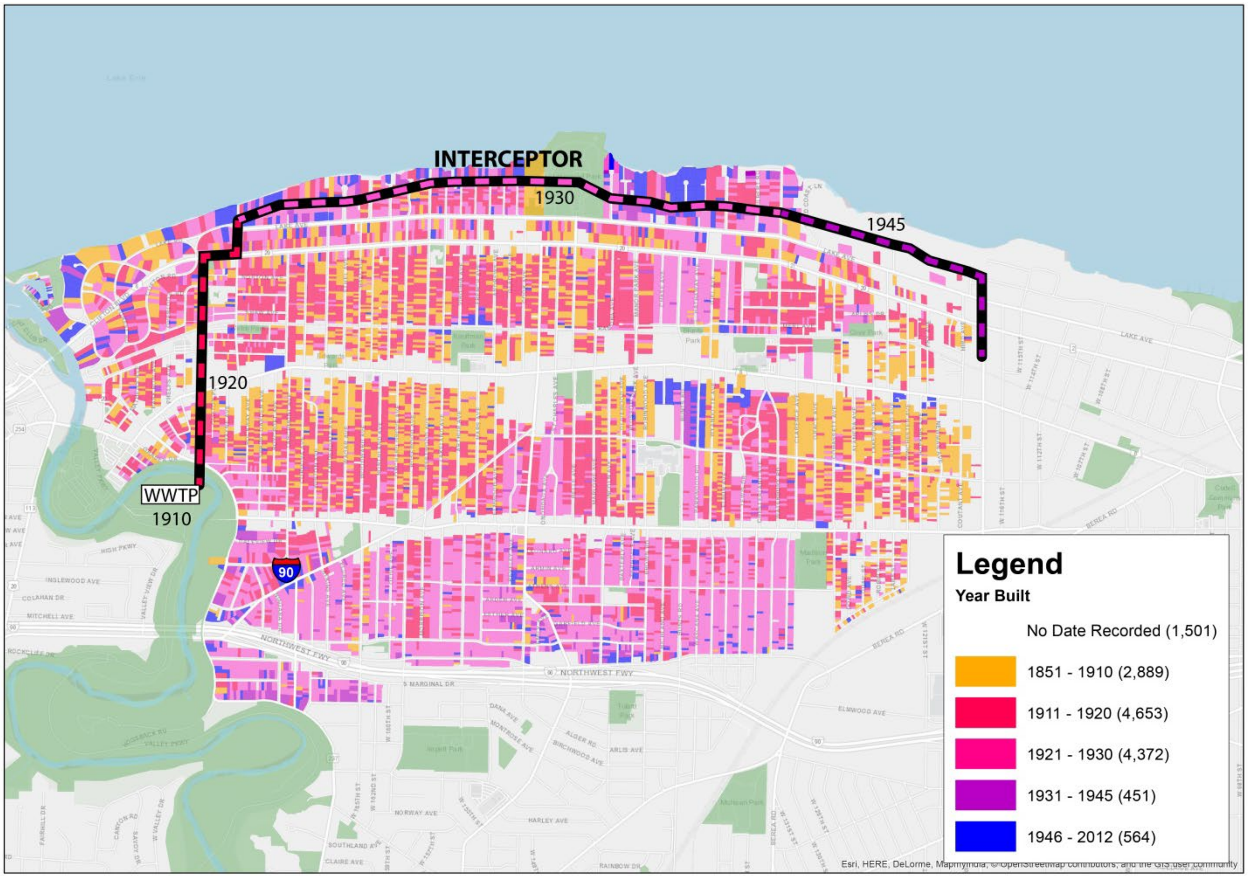


FIGURE 2-3. Stitching together Lakewood's 'system'

As shown in Figure 2-3, many of the neighborhoods in Lakewood were built prior to the completion of the 1960s-era wastewater treatment plant (WWTP) and the majority of the houses were built before the interceptor was completed in 1945. Lakewood's individual sewers were never designed to be an integrated system and there was no expectation they would function as such until the sewer interceptor linking the various phases was built in the mid-1930s (shown in Figure 2-4). Even then, the new interceptor was only built for dry-weather volumes as combined sewer overflows (CSOs) across the city remained.

FIGURE 2-4. Lakewood's interceptor under construction near the WWTP

Lakewood's collection system is a unique arrangement of more than century-old elements pieced together. Single-pipe combined sewers are intermingled in sewer sheds with common-trench, so-called "over-under" sewers. It is evident that there was no design intent for the under sewers to carry only sanitary sewage to a treatment plant during all weather events for the following reasons:

1. Connections to a functioning treatment plant did not exist.

2. Several engineered relief arms (Figure 2-5) from the under to the over pipe have been identified across the city as shown in Figure 2-6.

3. Private property infrastructure includes elements that were once state-of-the-art. For example, in the pilot project, expected to be representative of citywide construction, storm laterals have been found to have P-traps, which were intended to keep odors from sewage away from homes. Over time, these P-traps have clogged and seriously impaired the effectiveness of the stormwater system in keeping flow away from sanitary sewers. More generally, it was common practice to intentionally connect downspouts to sanitary sewers with the design intention of 'flushing' the sanitary pipes.

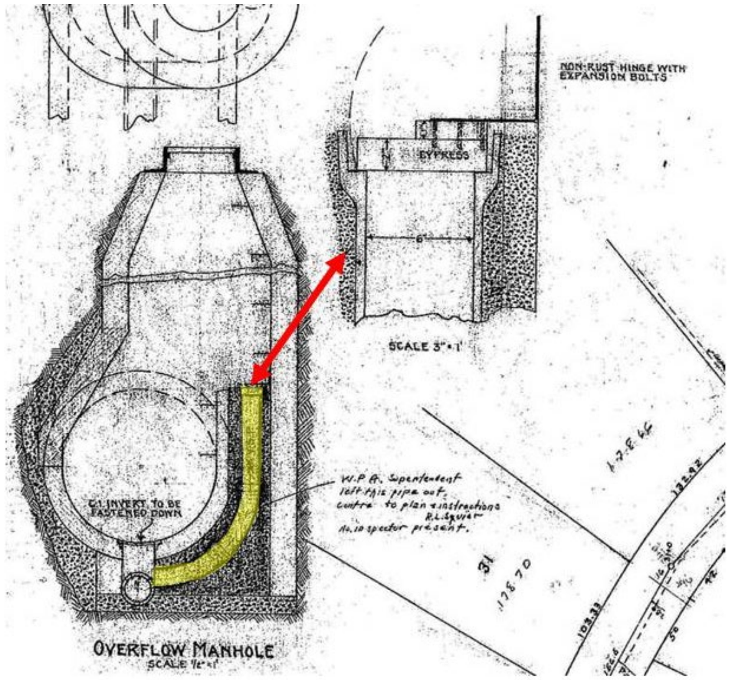


FIGURE 2-5. Identified designed relief arms built in throughout Lakewood's system

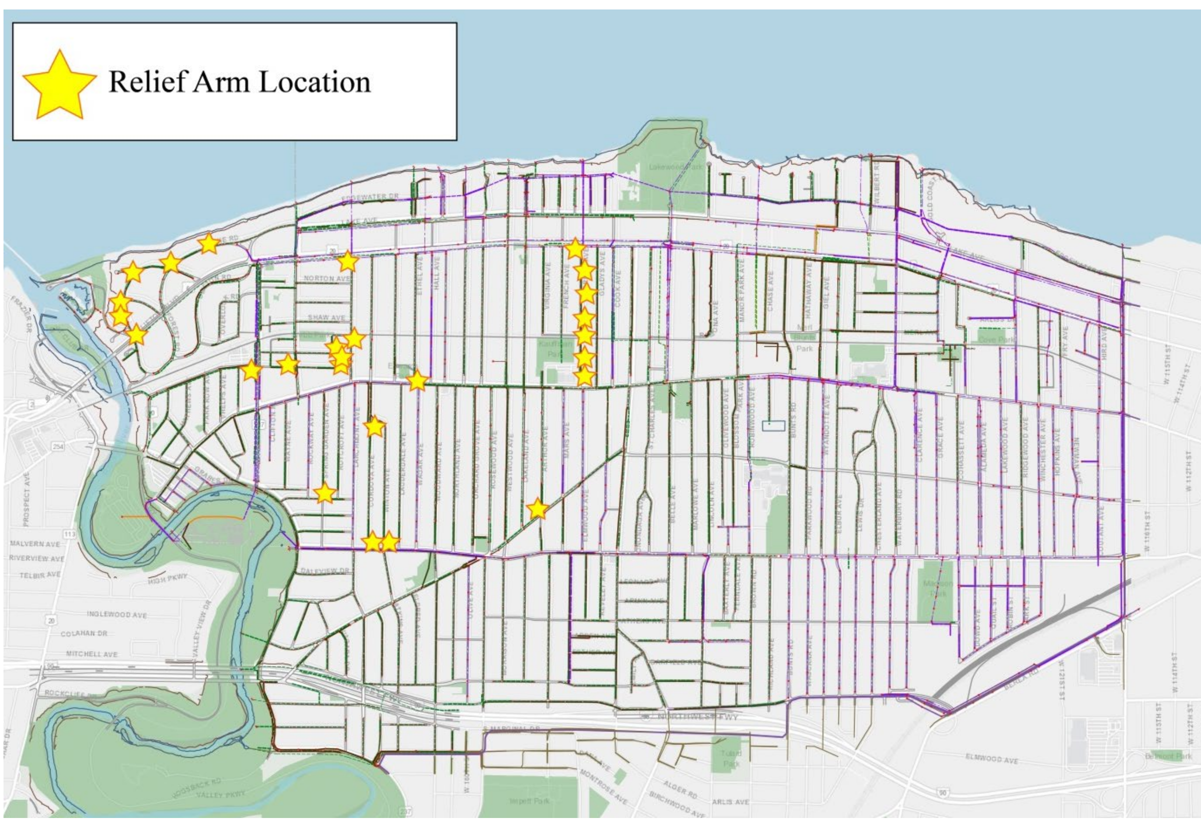


FIGURE 2-6. Map of relief arms identified to date throughout city

2.3 Stewardship and Ever-Improving Performance

Lakewood's appreciation of environmental stewardship has grown continuously, shown most dramatically by the before-and-after photos in Figure 2-7 of the lakefront's transition at Lakewood Park: from the 1940s city dump to the regional attraction of the Solstice Steps, both on the same site.

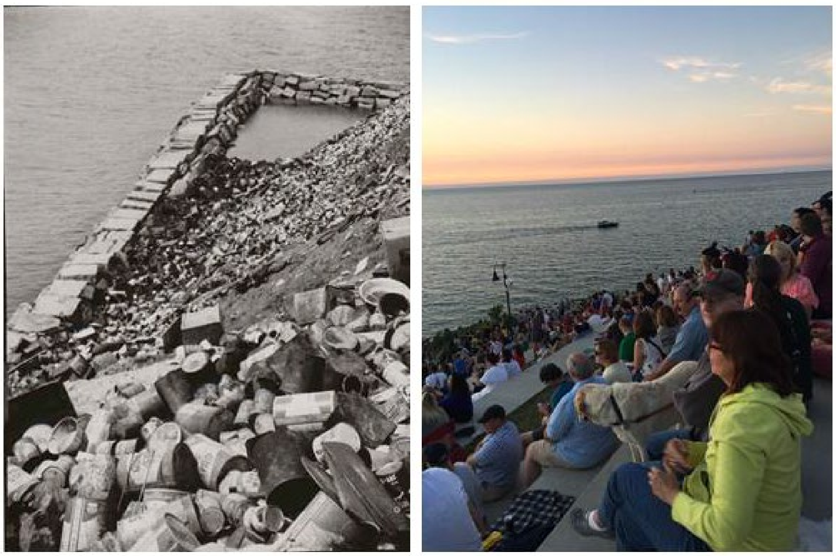


FIGURE 2-7. Lakewood city dump, 1935, and Lakewood Park Solstice Steps, today

The city has made tremendous progress towards protecting our surrounding waterways over the past 100 years. As explained in section 2.3.2, the city administration has taken productive steps to continuously improve the operation of the infrastructure it inherited. However, varied situations at the street and household levels bring persistent engineering and financial challenges.

2.3.2 Despite Atypical Aspects, Lakewood's System Performs Well

Lakewood's system performance has shown incremental improvement over the past 20 years. The percent capture has increased from 79 percent in 2003, to 83 percent in 2011 with the WWTP expansion, to 85 percent today with the addition of the Lake Avenue and aerial sewers. The existing percent capture of the system will increase with the planned high-rate treatment (HRT) facility at the WWTP. The city has achieved this level of control while being extremely diligent to reduce basement backups. Capacity-related basement backups are rare, and Lakewood continues to view this as a public health priority.

The Lakewood sewer system treats a very high percentage of the flows and, more importantly, pollutants. The water quality of the surrounding water bodies has improved as the region has prioritized water stewardship. The Rocky River, where it borders Lakewood, is in attainment of aquatic life use standards. Lake Erie's Clifton Beach, located just east of the mouth of the Rocky River in Lakewood, is monitored for water quality by the Cuyahoga County Board of Health. The monitored beach rarely reports occurrences above the *E. coli* limits.

The unique system configuration found in Lakewood requires alternative performance measures. As explained more fully in a later chapter, the best measure of success is a set of metrics that include the system capture of sewage carbonaceous biochemical oxygen demand (CBOD). Under that measure, the current system removes 93.7 percent of Sewage CBOD during wet-weather events. After the installation of the HRT facility, the system removal estimate increases to 94.1 percent for Sewage CBOD. Additionally, other alternatives outlined in this IWWIP will increase capture to 97.5 percent Sewage CBOD, which is the functional limit of Lakewood's system and WWTP.

2.3.3 Environmental Progress has been Continuous

The city's administration has worked for the past 10 years to institute processes that achieve the spirit and letter of the CWA on an affordable and sustainable path. Since 2003, the city has spent $60 million on capital improvements for the sewer and wastewater system. There are also several approved projects, currently in process, including the $24 million HRT facility that has been bid and is in the initial stages of construction.

In 2015, the city invested $1.3 million to separate combined sewer flows in the tributary area of CSO 056 on Edgewater Drive. The project entailed separating the over-under sewer flows at five intersections with Edgewater Drive that were connected to a combined sewer dropping into the interceptor. The separation project removed the storm flows from the sanitary sewer system for 100 homes in the CSO 056 tributary area.

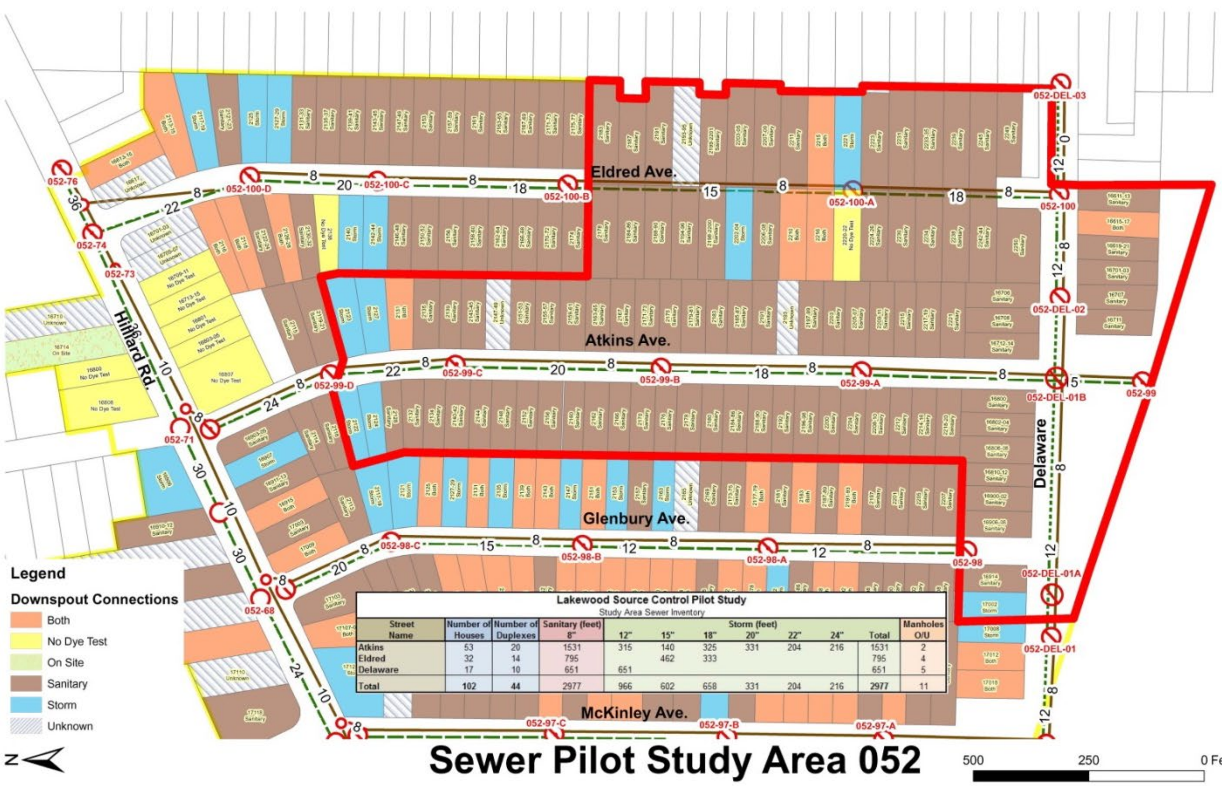
FIGURE 2-8. West End aerial sewer

In 2016, the city invested $6.1 million by constructing the West End CSO elimination aerial sewer. The construction of the aerial sewer shown in Figure 2-8 addressed outfalls CSO 053 and 054, eliminating 3.5 million gallons of combined wastewater from entering the Rocky River. This project controlled two of the three CSOs discharging to the Rocky River to zero overflows in a typical year.

In 2018, the city invested $1 million by diverting stormwater flows south of Lake Avenue that were originally flowing to the interceptor. The new 36-inch-diameter storm sewer now carries the flows along Lake Avenue to the storm outfall at Lakewood Park. This work was integrated with the resurfacing of Lake Avenue. This project reduced overflows at CSO 058.

2.3.4 Source Control Pilot study is Cutting-edge Effort

Source control is a private property control strategy that is rooted in the understanding that the rooftops of Lakewood's 17,000 structures are the largest collector system in the city. A pilot study is being conducted to assess the cost versus effectiveness of this alternative, the extent of which is shown in Figure 2-9. Lakewood is concluding Phase 2 of this study. Continued analysis of the remaining work and its impact is underway.



Street Name	Number of Houses	Number of Duplexes	Sanitary (feet) 8"	Storm (feet) 12"	15"	18"	20"	22"	24"	Total	Manholes O/U
Atkins	53	20	1531	315	140	325	331	204	216	1531	2
Eldred	32	14	795		462	333				795	4
Delaware	17	10	651	651						651	5
Total	102	44	2977	966	602	658	331	204	216	2977	11

FIGURE 2-9. Pilot study project area

The pilot area study corrections suggest a combination of private property work and public sewer rehabilitation may effectively reduce the amount of extraneous storm water entering the sanitary system. The necessary improvements consist of the following (Figure 2-10):

- Relining the private sanitary laterals as well as the public sanitary sewers
- Removing the traps in the stormwater laterals and cleaning the rest of the lateral
- Removing stormwater connections to the sanitary sewer
- Providing sump pumps, discharging to the storm lateral for any homes which have footer drains below the storm lateral invert
- Providing separate storm manholes at each shared manhole to prevent commingling of flows at the invert plate locations

Construction is expected to be complete in the first half of 2019. Post-construction monitoring will be started immediately. A more complete post-pilot project report is expected in 2019.

Results of the pilot study to date have demonstrated that private property source control can be very expensive in terms of time and money. Each property has idiosyncrasies. Delivering improvement on private property involves significant personal disruption to the property owners. Funding and implementation have fundamental political and equitable dimensions. Despite the many vagaries, source control is the identified component of the IWWIP as the cost-effective solution for numerous overflows, but they are smaller and lower priorities. Lakewood will continue to grapple with all the integrated issues regarding the implementation of source control approaches in the years to come, in particular looking for affordable and equitable ways to sync private property plumbing improvements with other reasonable investments in century-old housing stock.

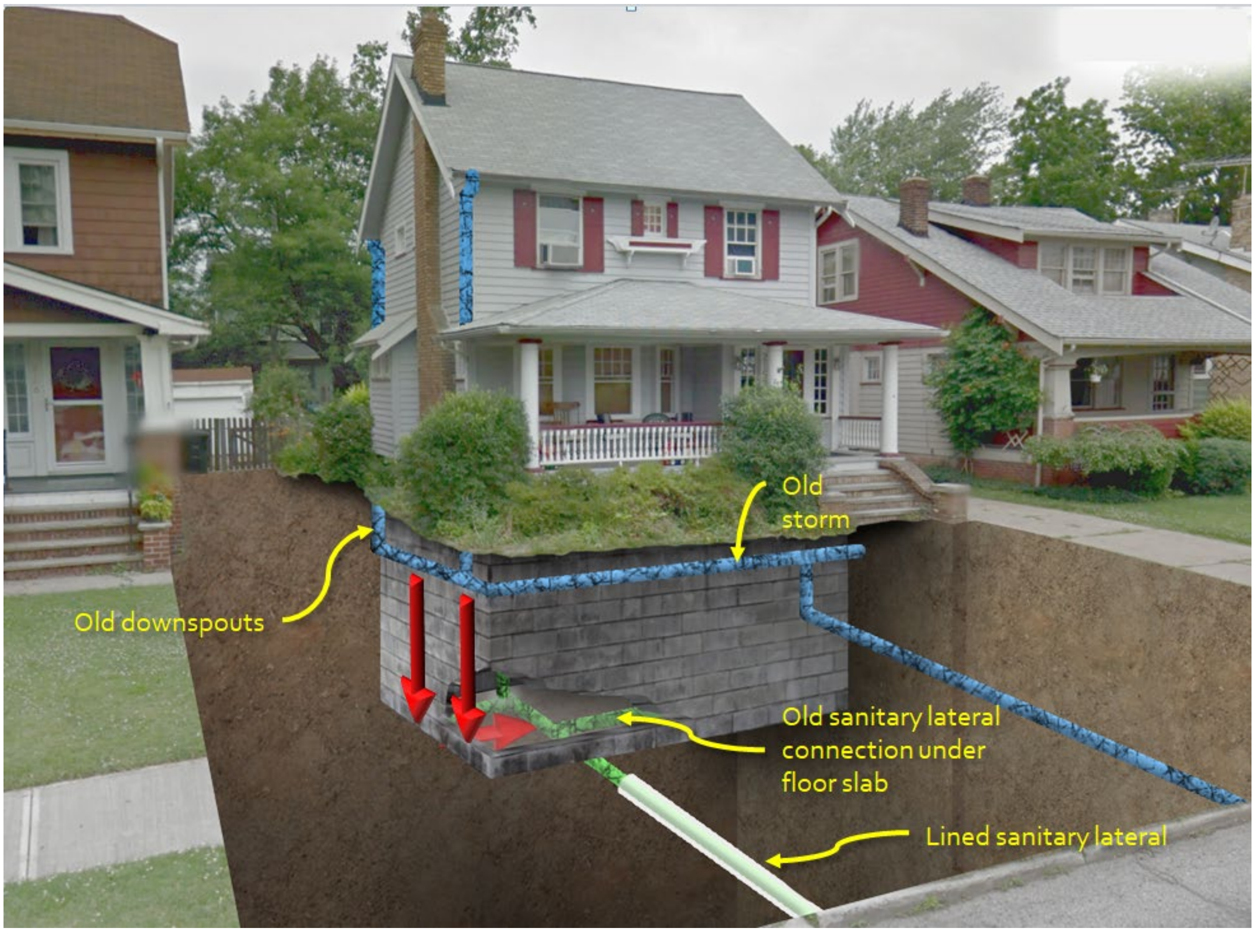


FIGURE 2-10. Typical Lakewood residence in pilot area

2.4 CURRENT OPERATIONS AND MAINTENANCE MAXIMIZE UNIQUE SYSTEM PERFORMANCE

Lakewood's progress is evident in the maintenance, operations and improvement of its existing system using industry best practices and innovation peculiar to Lakewood.

2.4.1 CONTINUOUS INVESTIGATION AND MODEL DEVELOPMENT

As explained in detail in Chapter 5, Lakewood has invested several years of effort to understand its complex, unique system in detail. That understanding is the basis for Lakewood's extremely detailed "all-pipes" model that enables alternatives analysis even involving changes on private property parcels. These investigations and modeling efforts position Lakewood to make cost-effective improvements without increasing risk of basement backups.

2.4.2 MANHOLE INSPECTION UPDATE

In 2018, the city created a GIS app to input and collect manhole information with iPads in the field. The intent of the application is to identify the location and type of manhole, the piped connections entering and exiting the manhole (size, type, and depth), the presence of weirs and invert plates, and the condition of the manhole infrastructure. The information collected is uploaded into the city's GIS system to be integrated with the city's infrastructure maintenance and replacement program.

2.4.3 CMOM Implementation

The city's collection system operation and maintenance manual (CMOM), in place for many years, has been updated at the end of 2018 with the latest revisions to Lakewood's sewer system. The CMOM tracks maintenance performed and assists with scheduling future maintenance needed to maintain the sewer system in optimal state. The CMOM updates include adding the projects performed since the 2016 update. The CMOM updates include adding new areas that are routinely checked and evaluated.

2.4.4 Manhole Separations and Sewer Infrastructure Rehabilitation

With the city's water main replacement projects, manhole separations are being performed where the over-under sewer configurations exist and where hydraulically feasible. The city uses the hydraulic model to determine the existing hydraulic grade line at various storm events. Then a model is created using the planned improvements. The hydraulic grade line is checked at the previous storm events to determine if there is a negative impact from the planned improvements. If there are no negative impacts, the manhole separations proceed (Figure 2-11). Likewise, during the plan development stage of the water main replacement projects, the sewer mainline system is televised by companies certified by National Association of Sewer Service Companies and scored using the Pipeline Assessment Certification Program (sewer mains) and Manhole Assessment and Certification Program (manholes) standards. Based on the results, point repairs and sewer and manhole Cured In Place Pipe (CIPP) lining are added to the bid package to reduce inflow and infiltration (I/I) and rehabilitate the sewer infrastructure. The city leverages funds from the Ohio Public Works Commission in 0 percent, 20-year loans and grants to complete the work. Additionally, where private development connects into the city mains at manholes, manhole separation work is completed. Since the IWWIP Phase 1 submission, seven street segments have had manhole separations with a total of 38 manhole separations performed.

FIGURE 2-11. Manhole separation

2.4.5 Regulator Modifications

Through the overflow monitoring program and hydraulic modeling, the city has identified 19 locations where modifying the manhole, improving the manhole configuration, or separating the manhole will eliminate or reduce CSO flows and not have a negative impact on the hydraulic grade line. This project includes manhole separations, raising of weir walls (to prevent modeled typical year overflows from occurring), reconfiguring the manhole to separate flows, removing hydraulic brakes, removing choke points, replacing deteriorated and undersized sanitary sewer sections, and rehabilitating manholes to reduce I/I. The project is expected to be bid in late 2019 and be constructed by the end of 2019.

2.4.6 MS4 Compliance and Illicit Discharge Detection and Elimination

Lakewood remains in compliance with its MS4 permit requirements. In particular, as of 2018 Lakewood had eliminated all identified illicit discharges.

2.5 Wet-Weather Analysis is Integrated with Redevelopment for Best Results

2.5.1 Green Infrastructure and Lakewood's Community Vision

Green infrastructure is baked into every development that exceeds 8,000 square feet in size. Lakewood's building code at Chapter 1339 exceeds State of Ohio standards in stormwater management requirements. Over 20 major projects have been built since this code was enacted and every new project since has complied with the best management practices (BMPs) found within this code, as shown in Figure 2-12.

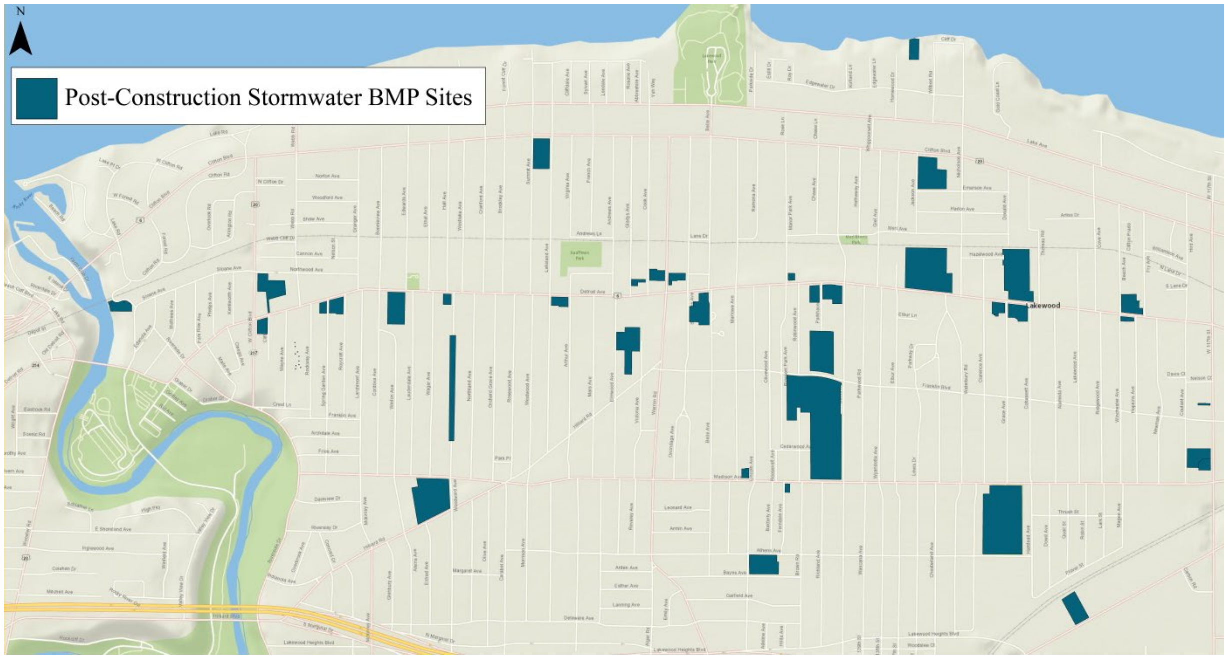


FIGURE 2-12. Lakewood's post-construction BMP sites

Some examples are the following:

- McDonald's on Detroit Avenue (Figure 2-13)
- All 11 new school buildings
- CVS on Detroit Avenue
- Beck Center for the Arts
- Public parking lots 1 and 2 (Figure 2-13)
- Dunkin' Donuts on Detroit Avenue
- Madison Park (Figure 2-13)
- Lakewood Park
- Lakewood YMCA

FIGURE 2-13. Green infrastructure on public and private property throughout Lakewood

Lakewood's clear vision with respect to achieving cost-effective wet-weather improvement was captured in the city's Community Vision. This work, like the IWWIP, was the product of extensive public engagement among Lakewood's very active citizenry. The Community Vision guides land use decisions throughout the city. Some of its goals and objectives related to local water stewardship are listed in Figure 2-14. The Community Vision is available at vision.onelakewood.com.

COMMUNITY WELLNESS GOALS & OBJECTIVES

- Educate about the responsibility of maintaining sewers citywide
- Adopt environmental best practices
- Expand available greenspace
- Consider small-scale community-based solutions to help alleviate storm runoff including the use of rain barrels, bio-swales, storm water retention, and permeable pavements
- **Become a regional leader regarding storm water management**

FIGURE 2-14. Lakewood's Community Vision focuses on water stewardship

2.5.2 Infrastructure Integration

Lakewood has demonstrated its resolve to face hard issues head-on. The transition of our beloved community hospital was precipitated by momentous shifts in healthcare regulation, funding, technology, and healthcare needs. This was a hard truth that was thoughtfully addressed to achieve major transformation from inpatient care to outpatient-centered care. This includes the demolition and redevelopment of the site with a $70 million mixed-use project.

The city has partnered or facilitated several major housing developments in very tight spaces, from razing obsolete schools and auto dealerships into high-density townhouse developments, which have all been sold. Vibrant neighborhoods are a cornerstone of Lakewood's ability to meet its current obligations and position itself for future success.

As the city's team becomes aware of large development sites, the team performs a preliminary analysis to determine if additional stormwater storage on the site would be beneficial to Integrated Planning. At the east end of the city, a church property was recently identified as a potential site for future sewer infrastructure when the congregation disbanded in 2018. The city is currently under contract to purchase the site and integrate potential storage with a community center. But in Lakewood, fully built-out with century-old buildings, this cannot just be a "sewer project." The current facility also may be suitable for a much-needed community center and other social service functions, as it is located among the highest concentration of seniors in the community. Retrofitting the church property to become the city's facility requires an evaluation of proper present-day expenditure in light of the still-evolving needs relating to the IWWIP. This is the very essence of the Integrated Planning that Lakewood, by its circumstances, is compelled to undertake and which it has been doing effectively for decades. Lakewood must be flexible and adapt to land use changes which might only occur once in a century. Every project affecting sewers can affect surface uses, and vice-versa, so Lakewood does not have the financial resources to get anything less than the most from every improvement.

The One Lakewood Place project at the site of the former Lakewood Hospital is a great example of the city's approach to delivering large-scale project with the type of community input that is involved. This 5.6-acre site (which is large for Lakewood's built-out and dense environment) is currently under review to be rezoned as a planned development for a $72 million mixed-use development. As part of this project, thanks to community input, the historic Curtis Block building will be rehabilitated. The selection process to choose a partner to develop the property, led by a resident panel, took a full year, and the public engagement to shape the development has taken an additional year. Abatement is underway on the property and construction is expected to begin in 2019. The new developments occurring around Lakewood provide great opportunities to include stormwater control where there previously was none and upgrade city infrastructure.

2.5.3 Reinvention as a 21st-Century City Requires Full Integration of All Community Development and City Services.

Lakewood's ability to plan for improvement in the coming years starts with sustaining vibrancy today. Public safety investments are of paramount importance, including the maintenance of full staff levels for police and fire and upgrading of equipment, to ensure effectiveness and reliability. Speed of response, strength of numbers, efficacy of investigation, vigilance of patrol--all of these components contribute to a safe and secure Lakewood and our community's overall vitality.

Lakewood has the full range of municipal utility responsibilities:

- Drinking water system (120 miles of water mains), sewer system (160 miles of sewer mains), waste treatment system (40 MGD capacity primary, secondary, and tertiary treatment).
- A recent $3 million upgrade of our drinking water meters to an automated reading system utilizing radio frequency technology has boosted our efficiency and allowed for much earlier leak detection.
- Each system cannot be ignored or deferred to favor the others.
- The $7 million rebuilding of the solid waste digester system created an opportunity to add sustainability and resiliency by capturing the methane byproduct and divert it to a fuel source that will power 30 percent of the WWTP.
- Lakewood invested $19.5 million to upgrade century-old water mains between 2006 and 2016.
- Lakewood invested $20 million in street resurfacing projects since 2011

Lakewood has an energized and active citizenry that has helped it deliver on projects, from planning to reality. Over 200 citizens serve on the city's boards and commissions. The city's boards and commissions, task forces, and non-profit partners provide dynamic assistance in programs like Clean Water Lakewood. A sampling of these groups and their roles is provided below:

Clean Water Lakewood

The Clean Water Lakewood task force is a group of Lakewood residents and business owners assembled to help identify the best paths forward for water infrastructure in Lakewood. This group is focusing on facilitating best solutions for controlling sewage overflows.

Resiliency Task Force

The Resiliency Task Force was formed to research and plan for a more resilient city. This citizen-led panel is working on gaps in existing city plans, finding alignment between existing plans, collecting public input, and developing strategies and priorities to make Lakewood the most resilient city in Ohio.

Planning Commission

Planning Commission reviews requests for lot consolidations and splits, and determination of similar and conditional uses. They oversee the Community Vision and review the use of land across the city.

Architectural Board of Review

Architectural Board of Review considers architectural proposals and landscape plans for commercial and residential properties.

LakewoodAlive

LakewoodAlive is a community-centered nonprofit organization in Lakewood. Its mission is to foster and sustain vibrant neighborhoods.

Lakewood Tree Task Force
The Lakewood Tree Task Force has helped develop a comprehensive strategy to improve the tree canopy and add diversity to the variety of species around the city.

Lakewood Historic Advisory Board
Lakewood Heritage Advisory Board serves in an advisory capacity for the purpose of educating, informing, and making recommendations to the city on matters relating to historic preservation.

Keep Lakewood Beautiful
Keep Lakewood Beautiful promotes civic involvement through public interest in the general improvement of the environment of Lakewood.

The city strives to balance its dual responsibilities of environmental stewardship and public health with sustaining a flexible, affordable, and sustainable approach that is fair and equitable to the ratepayers, taxpayers and citizens of Lakewood.

Lakewood has already achieved significant progress in fully integrating this balance into all its municipal and community functions, as reflected in its Community Vision and multiple new installations of post-construction BMPs. The goal of this IWWIP is to chart the path for Lakewood's continued success.

CHAPTER 3 – LAKEWOOD AND NORTHEAST OHIO ECONOMIC AND AFFORDABILITY CHALLENGES

Lakewood is primarily a bedroom community for neighboring Cleveland and the northeast Ohio region. The economic conditions of Lakewood are inextricably linked to those of Cuyahoga County and Cleveland, with which Lakewood shares a large percentage of its borders as shown in the map presented in FIGURE 3-1. Lakewood has made significant investments in its education system, parks, and other public infrastructure to be able to maintain its economic vitality despite trends in Cleveland and Cuyahoga County that pull in the opposite direction. Given this reality, Lakewood's vibrancy and its ability to sustain infrastructure improvement is in a fragile position.

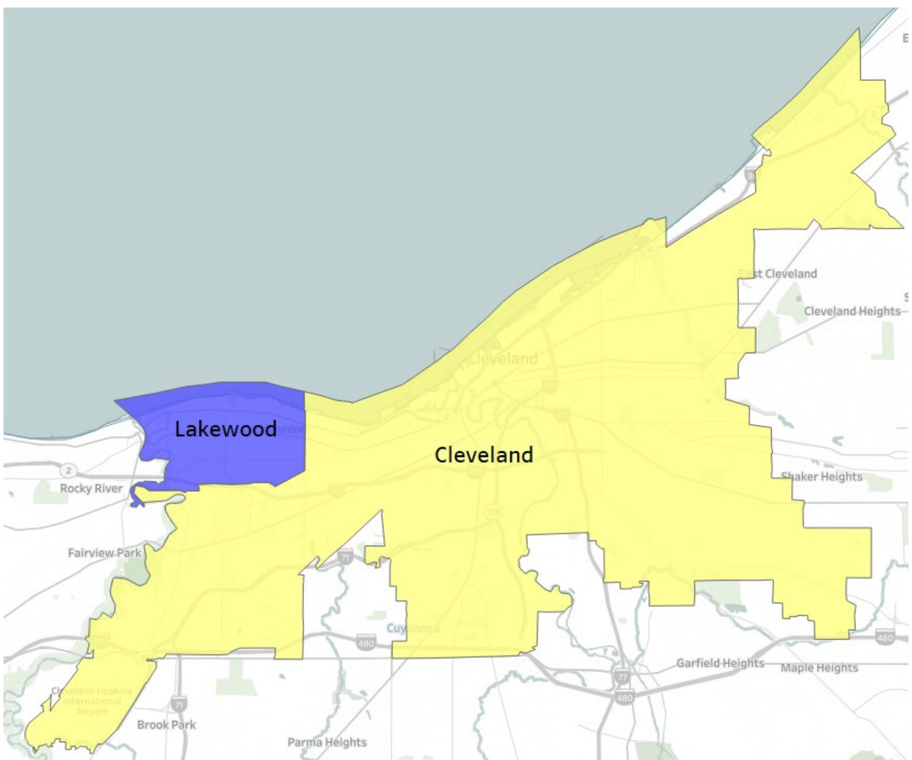


FIGURE 3-1. Lakewood and Cleveland city limits

This chapter examines the demographic and economic challenges confronting Lakewood in the context of examining Lakewood's financial capability and its unique local affordability factors.

3.1 Population Challenges in Cuyahoga County

In the two decades before and following World War II, the population of Cuyahoga County rose drastically due to the abundance of manufacturing jobs offered in Cleveland and the surrounding areas. The region's population growth peaked in the early 1970s then began a steady decline as America's economy transformed from a manufacturing to a service-based economy. FIGURE 3-

2 illustrates the correlation between the reduction in the percent of the labor force working in manufacturing and the population of Cuyahoga County. The resulting population change for the county is a continuous annual decline rate of 0.68 percent from 1970-2017.

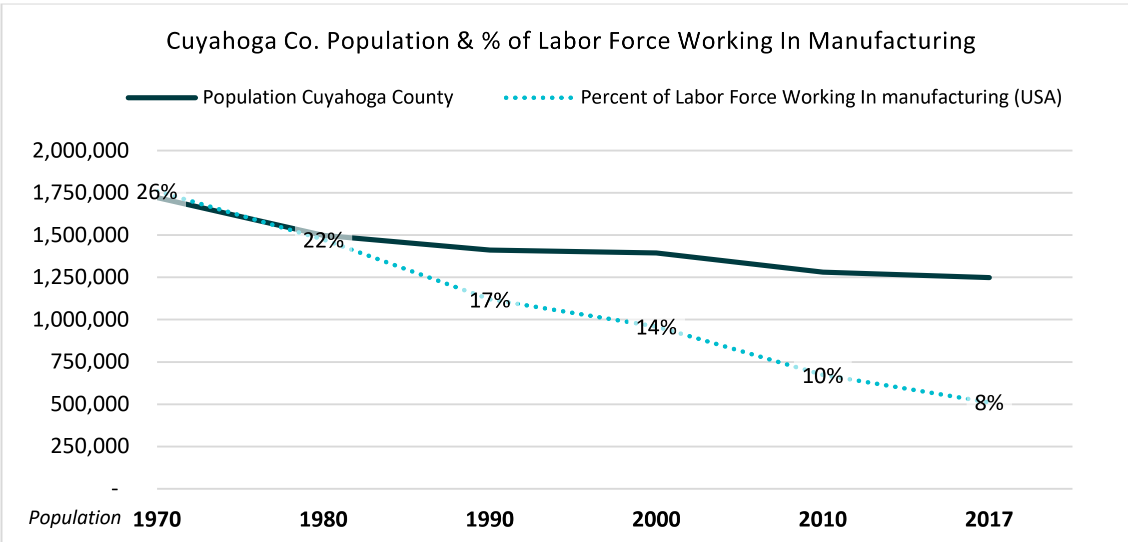


FIGURE 3-2. Cuyahoga County population and labor force working in manufacturing[1]

Lakewood's population has declined by 0.69 percent annually since 1970, which is consistent with the region's population decline over the same time. The city's population is presented in the following graph along with the percentage change between each decade.

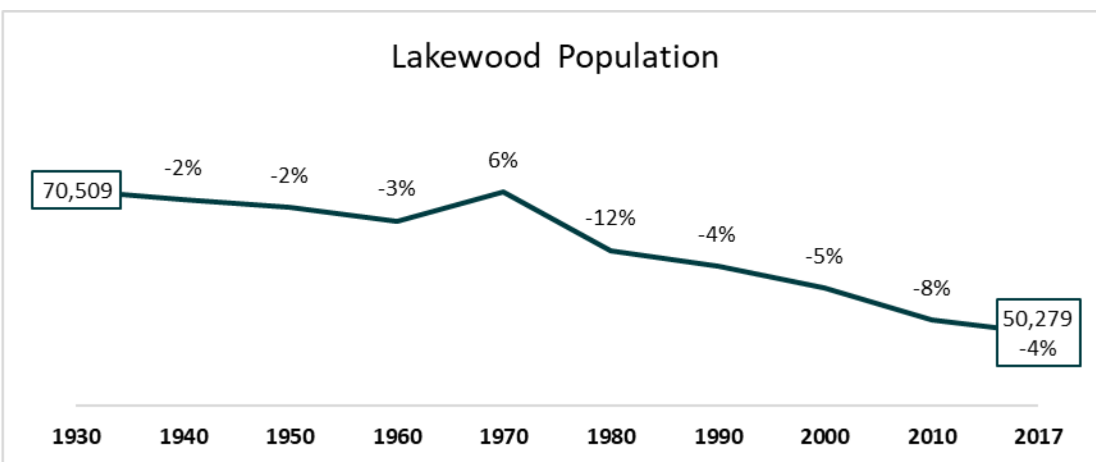


FIGURE 3-3. Lakewood Population, 1930 to 2017[1]

Zooming out from Lakewood, population trends across the state of Ohio since 1970 further illustrate the shift away from Lakewood and Cleveland to further distant suburbs and even out of

[1] US Census Bureau and Bureau of Labor Statistics

northeast Ohio all together. Since 1970, five of the six counties that border Cuyahoga have experienced population growth whereas Cuyahoga has a total reduction in population of 27 percent. This trend is emphasized further when considering data since 2010 that demonstrate the high-growth in central Ohio surrounding Columbus and southwest Ohio near Cincinnati and Dayton.

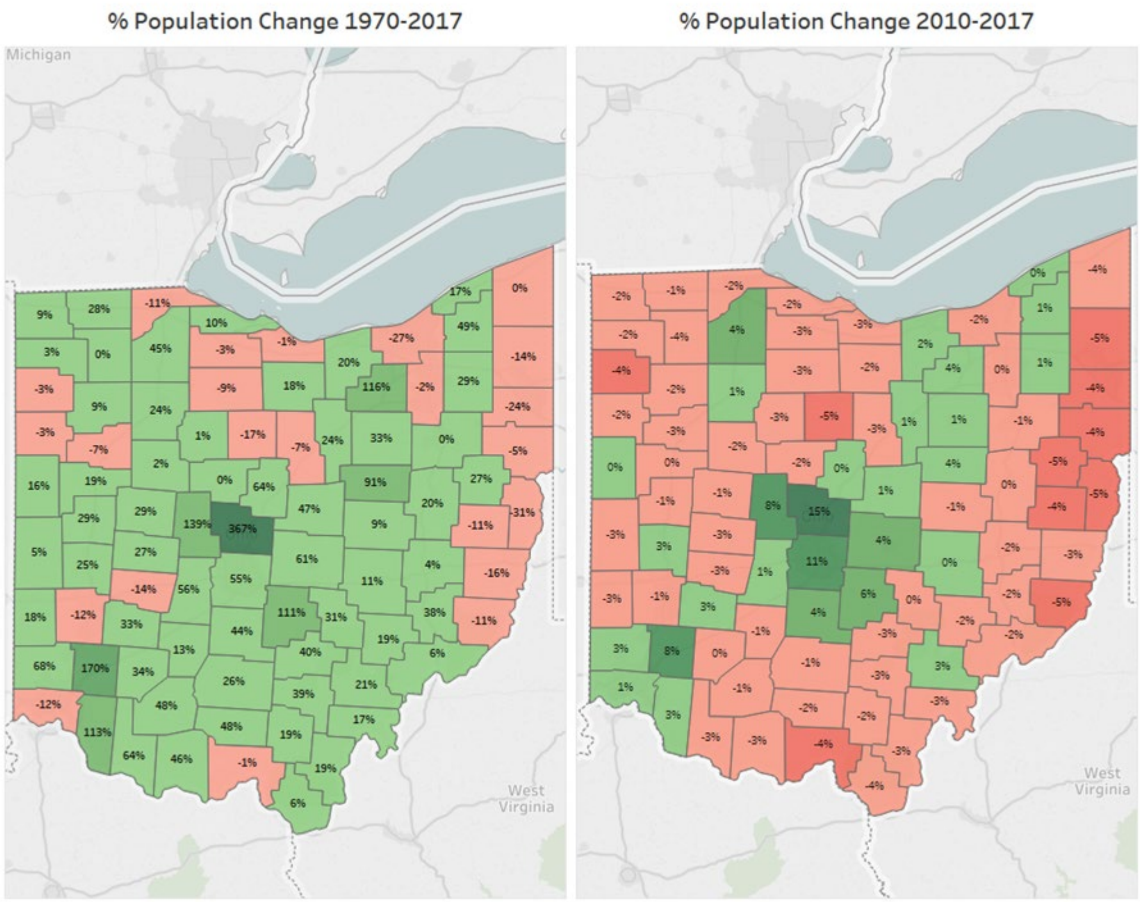


FIGURE 3-4. Population Change in Ohio Counties

U.S. Census Bureau's Flows Mapper depicts movement of population out of Cuyahoga County. Counties that lost people to Cuyahoga County on net from 2012 to 2016 are shades of orange and counties that received people from Cuyahoga County are shades of blue in Figure 3-5. FIGURE 3-5 demonstrates that between 2012 and 2016, Cuyahoga County lost significant population to each of the five surrounding counties (Lorain, Summit, Geauga, Portage, Medina and Lake). Significant population also left Cuyahoga County for Franklin County near the City of Columbus.

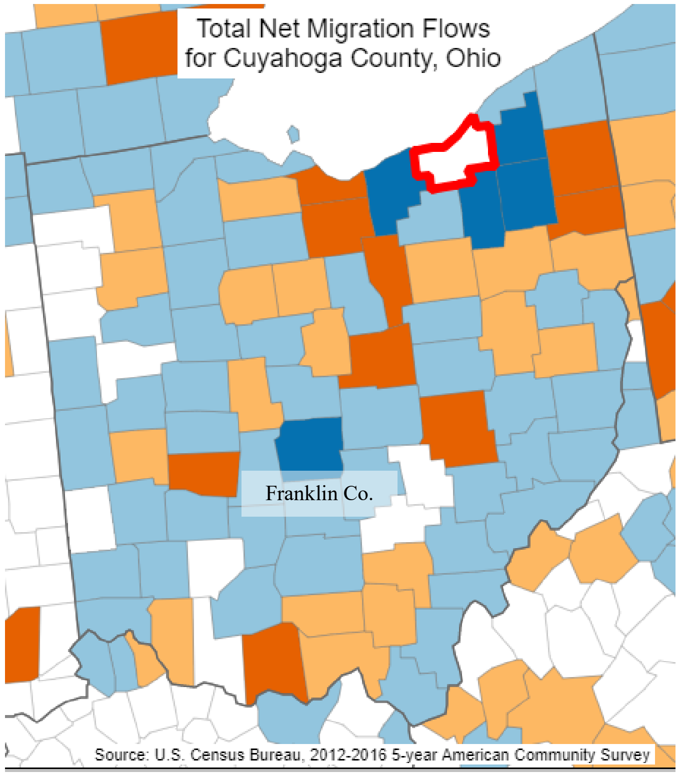


FIGURE 3-5. Population flows for Cuyahoga County, 2012-2016

3.2 How Does Lakewood Compare to the Region?

As a suburb of a major metropolitan center, Lakewood is made up of several diverse neighborhoods and an estimated population holding at roughly 50,000. Many residents live in Lakewood and work in downtown Cleveland or other parts of Cuyahoga County. There is no significant industry in Lakewood, where the largest employer in Lakewood is the Lakewood Board of Education. Total employment within Lakewood in 2017 was 11,736.[2] The majority of houses in Lakewood were constructed in the 1910s and 1920s and have provided homes to countless families in the century since their construction.

Median household income (MHI) across the city is approximately $47,800.[3] While the MHI in Lakewood is slightly higher than that of the county, it is approximately 6 percent less than Ohio's MHI and 17 percent less than the national MHI. Lakewood's MHI is slightly higher than the Cuyahoga County metric only because of the influence of its neighbor the City of Cleveland's MHI, which is $27,854. This is 42 percent less than the MHI of Lakewood and demonstrates the challenging nature of the local economic conditions. If Cleveland is excluded from the

[2] City of Lakewood, Single Audit Report, 2017, p. S31
[3] 2017 American Community Survey, 5-year average

Cuyahoga County MHI calculation, the county's MHI is consistent with national levels—again, much higher than Lakewood's.

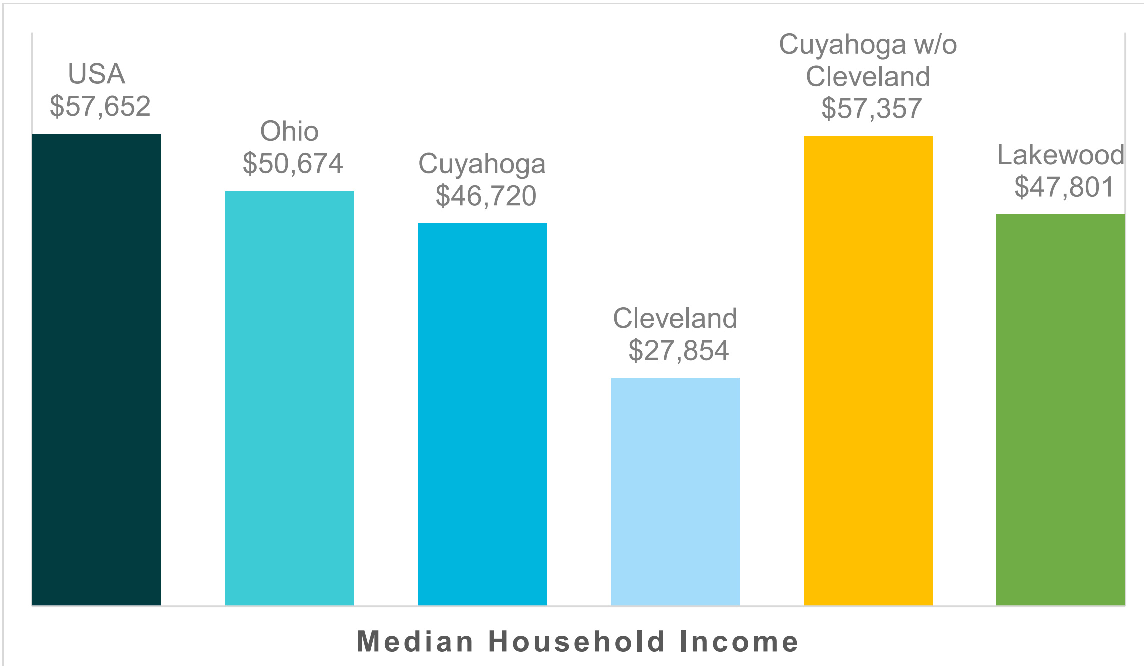


FIGURE 3-6. Median household income based on American Community Survey, 2013-2017

3.2.2 Lakewood General Fund under Pressure

Lakewood is a vibrant community with residents who are proud to call it home and who recognize and appreciate the community. But its vibrancy is fragile. Like many local governments in Ohio, Lakewood has been forced to generate significant local funding to make up for the loss of other revenue. The state government made changes to the state local government fund which resulted in $1.1 million less revenue for Lakewood in 2012 and $1.5 million annually since 2013; this is a total of over $10 million in the past seven years. The city also used to receive approximately $1.5 million in revenue annually from the estate tax, which was eliminated on January 1, 2013; this is a total of $6 million in average lost revenue through 2018. These changes are presented in FIGURE 3-7.

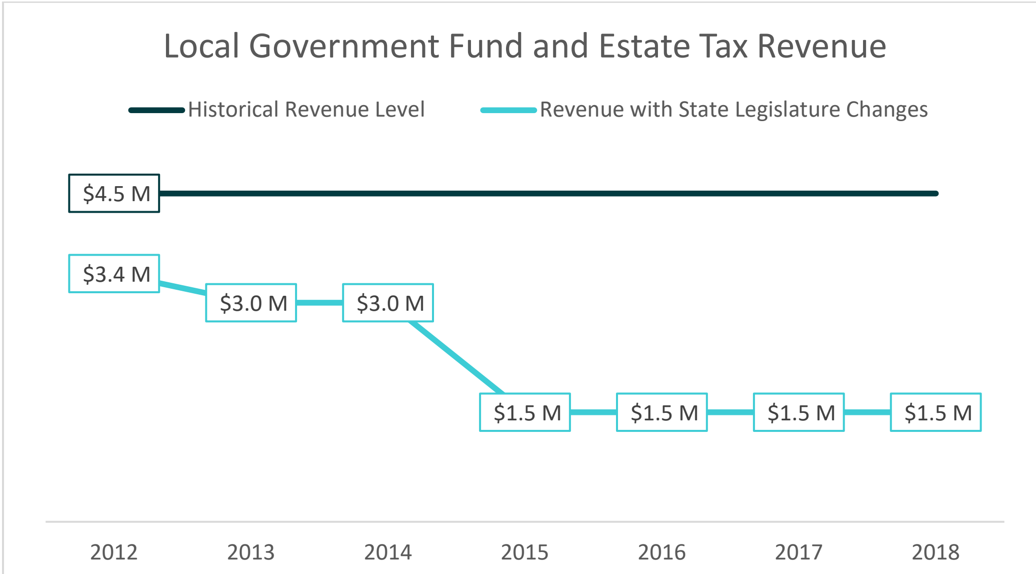


FIGURE 3-7. Lakewood local government fund and estate tax revenue

The more than $3 million of lost local revenues is a gap that will continue indefinitely. While this revenue is not used to support sewer enterprise fund operations and capital, it has required citizens to make a choice between cutting city services or approving increases in other fees and taxes to support the community.

Nearly two thirds of Lakewood's general fund revenue comes from its local income tax. This revenue has been at-risk as the population has steadily declined. As a result, the local income tax rate is currently 1.5 percent versus the 0.5 percent rate in 1970. It is important to note that Lakewood's income tax rate has remained steady for decades despite the economic challenges facing many Cleveland area suburbs, especially in the last decade. Several other local cities have increased income tax rates to above 2 percent and 3 percent in order to cover current obligations, but Lakewood has continuously structurally balanced its budget since 2008.[4]

The city residents have chosen to make difficult decisions during these recent years to be able to provide a quality of life and level of service that makes Lakewood attractive to new residents. Examples of these decisions include the Lakewood City Schools long-range facilities plan, a voter-approved referendum that began in 2003 and was completed in 2017. This plan made over $300 million in investments to rebuild all of Lakewood's public schools using multiple bond issues (including $50 million of state funding match). In 2019, Lakewood is embarking on a $75 to $100 million project to develop One Lakewood Place on the former Lakewood Hospital site. One Lakewood Place will be a vibrant mixed-use project in the heart of the downtown Lakewood district. Construction on the 5.7-acre property is expected to begin in 2019 and will include office, retail and residential amenities.

[4] https://www.cleveland.com/expo/news/g66l-2019/02/3dce1e34313479/after-sweeping-municipal-income-tax-rate-increases-across-ohio-where-does-your-city-or-village-rank.html

3.2.3 County Property Revaluation Leads to More Money Leaving Lakewood

A mandatory sexennial property reappraisal process was completed in 2018 for all parcels in Cuyahoga County. The countywide residential property value increased by an average of 10.8 percent; however, Lakewood was the community with the highest increase in property valuation as shown in FIGURE 3-8.[5]

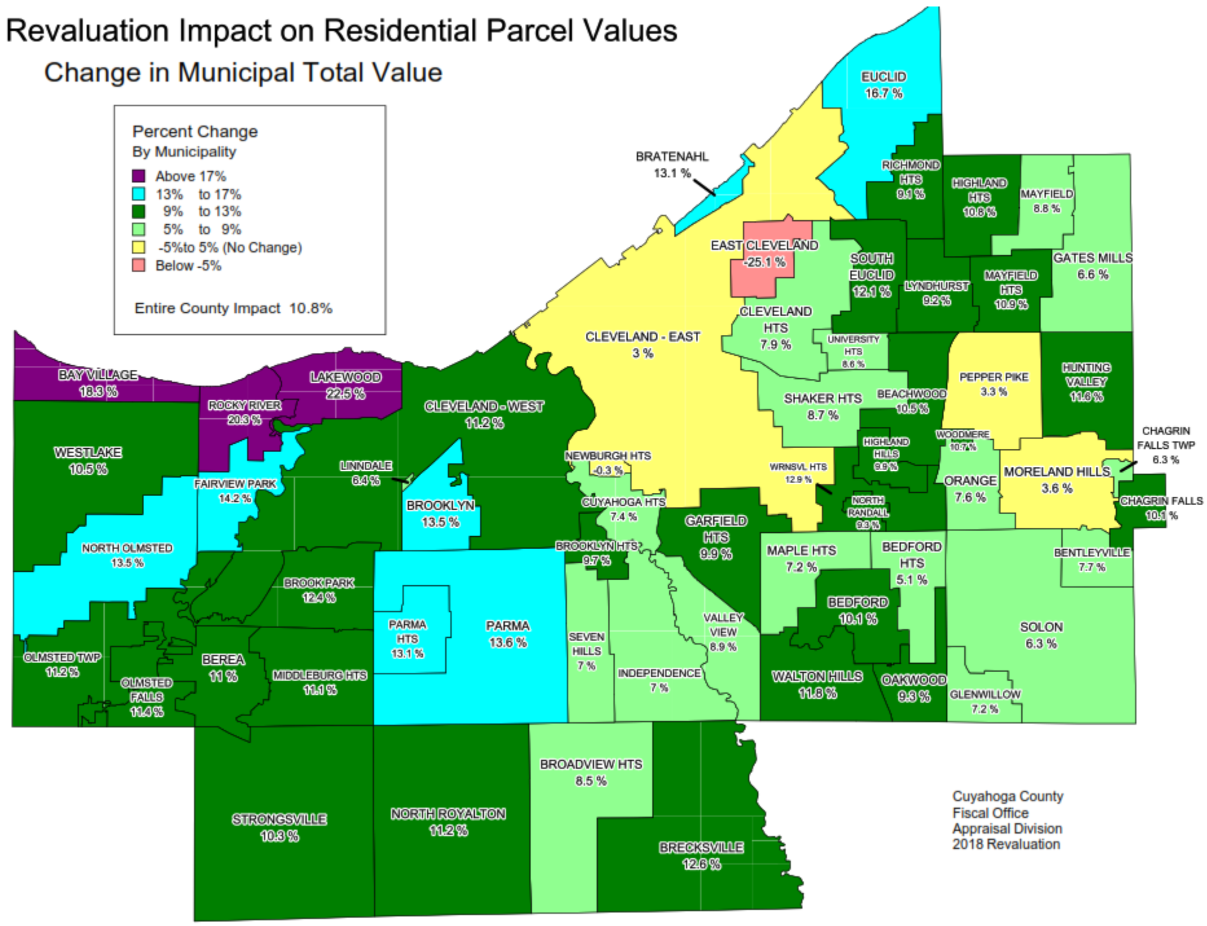


FIGURE 3-8. Cuyahoga County revaluation impact

On average, Lakewood residential property valuation increased by 22.5 percent with the reappraisal process. On one hand this demonstrates the vibrancy of the community in recent years. But in terms of forecasting trends, the result is that a struggling, depopulating county relies on a greater portion of county property tax revenue coming from Lakewood. This property tax increase is another burden on all Lakewood households that is without guaranteed benefit to the local community. In the same manner as the reduced revenue from the state, this is a change that will continue to impact residents indefinitely.

[5] http://executive.cuyahogacounty.us/en-US/2018-Sexennial-Reappraisal.aspx

3.2.4 A Transient City

Due to the high residential density of Lakewood, there is an abundance of housing options, particularly multi-family choices. As a result, a high proportion of Lakewood's population rent; only about 45 percent of households in Lakewood are owner-occupied. Lakewood has a vacancy rate of approximately 10 percent which is consistent with that of the state.[6] FIGURE 3-9 depicts this information.

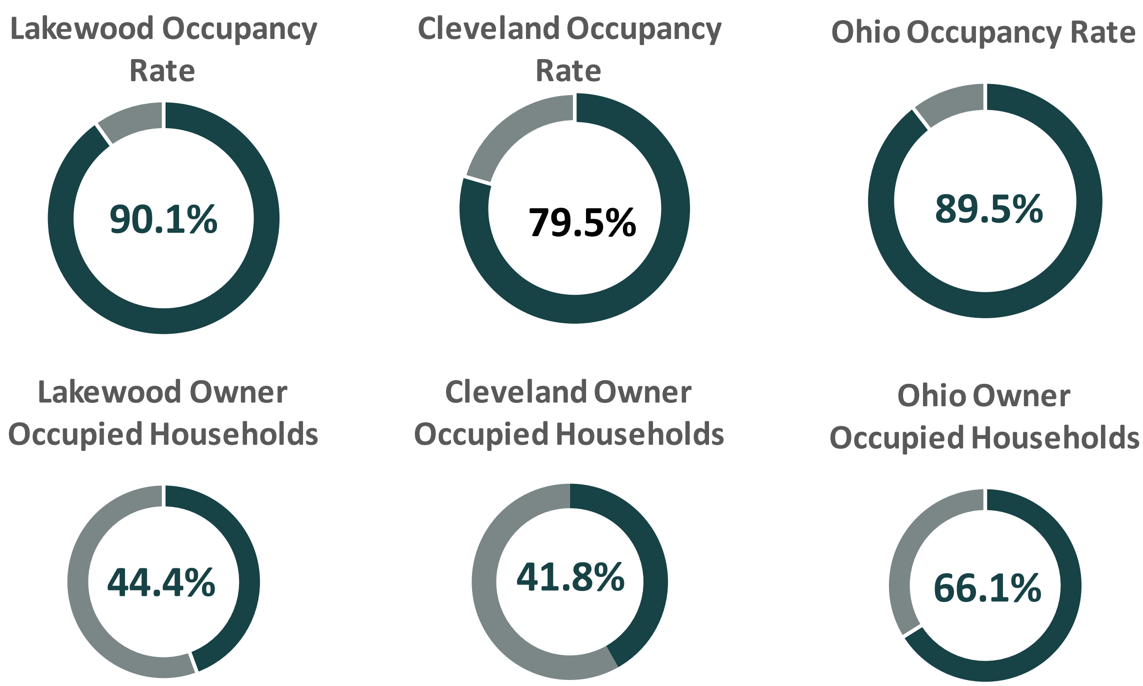


FIGURE 3-9. Occupancy and household ownership in Lakewood, Cleveland and Ohio

Greater population turnover can be expected for a population with a large portion of renters. FIGURE 3-10, based on Lakewood individual income tax return information, demonstrates that Lakewood's population experiences significant turnover each year.

[6] US Census Bureau, 2017 American Community Survey

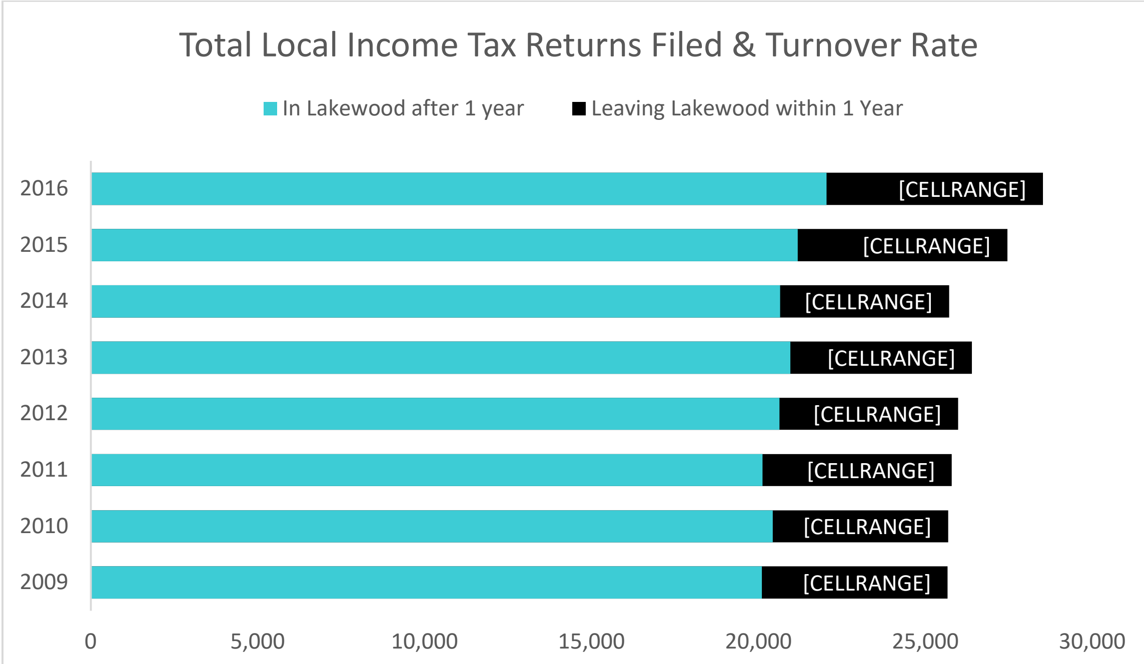


FIGURE 3-10. Individual local income tax returns, 2009-2016

Since 2009 Lakewood has had an average annual turnover rate of 21.3 percent and the recent trend is even higher. The inherent rapid turnover in the rental market makes Lakewood especially sensitive to rapid changes in rates, fees and costs. With such a strong multi-family and renter-based residential population, the city has always paid close attention to the impact any investment and policy will have on its rental markets. The increases in household costs to cover the loss of state revenue and the property re-appraisal will influence the cost of rental units throughout the city.

The water and sewer infrastructure investments proposed in the IWWIP and the need for asset management of 100-year-old infrastructure will also have significant impacts on city residents. These realities will lead to higher costs of rent throughout Lakewood, creating significant market risk in the fast-changing rental market. Any rapid escalation risks creating a negative loop where landlords forego investments—including necessary sewer investments on private property—in order to internalize mounting costs amid a dynamic and competitive rental market.

Recently, Lakewood has been an attractive choice for many young professionals. As a result, the number of one-person households has increased, and these are the most mobile of citizens. Being forced to make these improvements in too quick of a timeline could weaken the housing and rental market. FIGURE 3-11 shows the distribution of households in Lakewood by the number of persons.[7]

[7] US Census Bureau, 2017 American Community Survey

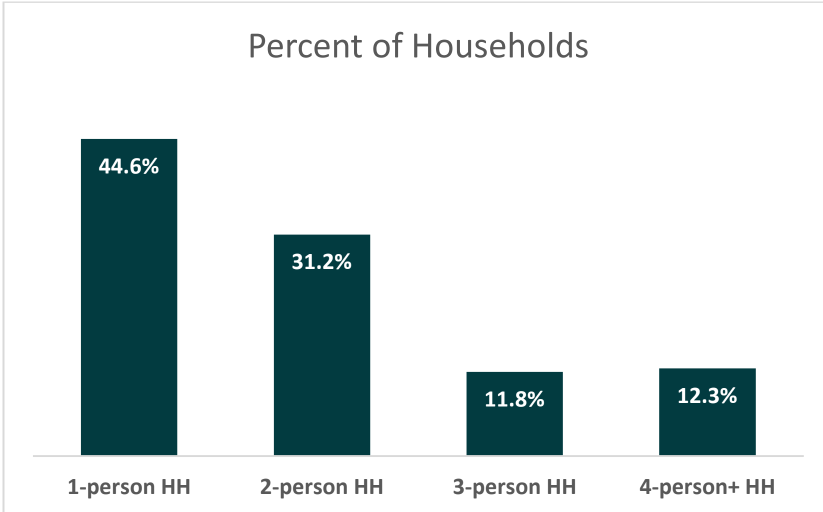


FIGURE 3-11. Lakewood household size

A high portion of Lakewood households are impoverished single-person households. The costs of major IWWIP capital investments will be borne by each household and those with only a single source of income will be placed at a higher risk for an inability to pay for service. Furthermore, single-person households can more significantly alter their water consumption patterns which influences system revenues, as demonstrated in this chapter.

3.2.5 Poverty and Unemployment in Lakewood

Lakewood has maintained its fragile vibrancy despite the regional population departures and other local household strains. Lakewood residents are more generally able to maintain jobs and avoid the highest poverty rates when compared to Cleveland and Cuyahoga County (seen in FIGURE 3-12 and FIGURE 3-13). The services and amenities that the city offers residents is why they have been able to maintain their modest economic strength relative to the region. The city remains an attractive place to live, in part, due to investments in its education system. The IWWIP has been developed so as not to disrupt this balance between amenities, services and the costs of living.

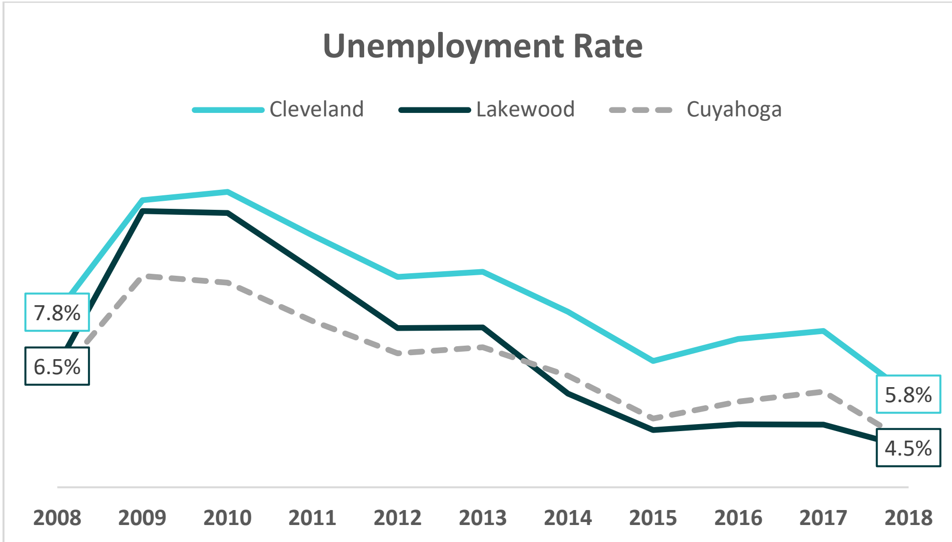


FIGURE 3-12. Regional unemployment rates

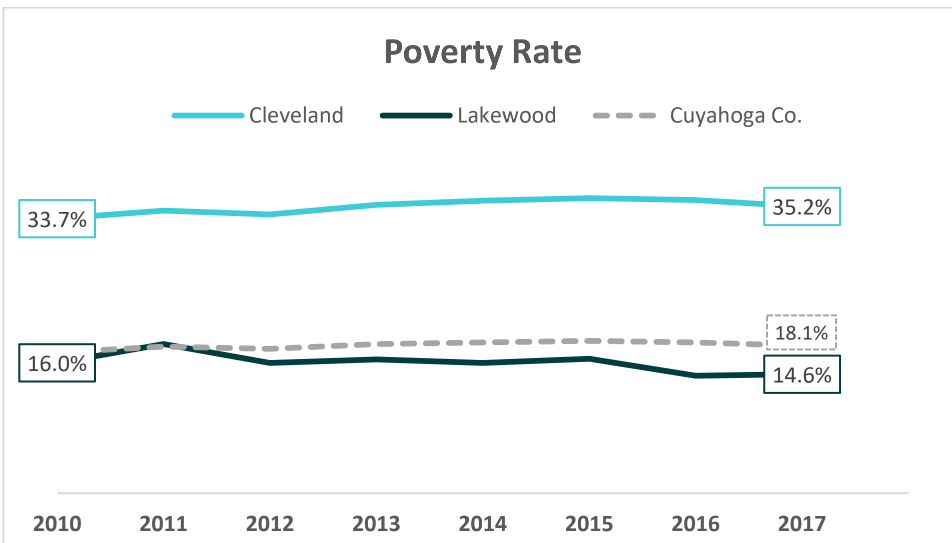


FIGURE 3-13. Regional poverty rates

3.3 Population and Declining Per Capita Water Consumption

As Lakewood's population has decreased during a period of increasing capital investment and improvement, Lakewood has proactively increased water and sewer rates. Furthermore, one of the biggest challenges facing water and wastewater utilities across the country is the trend of declining per capita water usage. Low-flow water fixtures, high-efficiency appliances, and more environmentally aware residents all contribute to this and there is no known bottom to the trend.

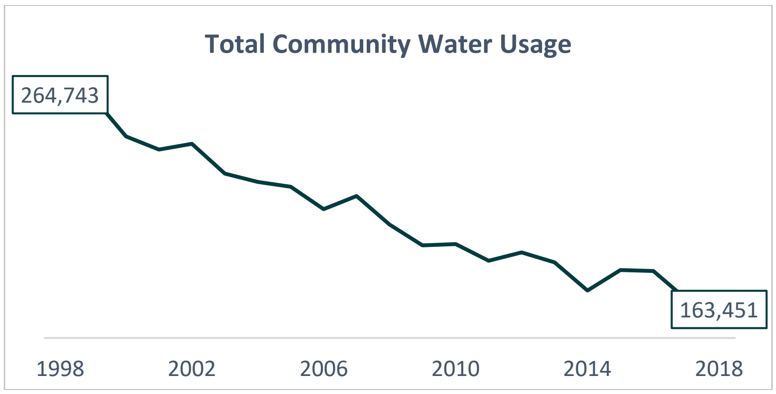


FIGURE 3-14. Lakewood water consumption

Annual water sales to Lakewood residents from 1997 to 2018 has decreased from 264,743 thousand cubic feet (MCF) to 163,451 MCF, which equates to an annual compound reduction of 2.4 percent (FIGURE 3-14). This continued loss of water sales revenue has adversely affected revenue stability for Lakewood which employs an entirely volumetric rate structure for both the water and wastewater systems. This reduction means that a rate increase of 5 percent may only generate 3 percent extra revenue. The city plans to explore alternative rate structures that will help stabilize the revenue and offer equitable recovery of the costs associated with managing wet-weather impacts.

3.4 Repair and Replacement of Aging Assets is a Critical Need

Much of the existing water and sewer systems, particularly the linear distribution and collection system, are reaching the end of their useful lives and the city recently completed a study of the capital improvement needs related to maintaining these water and sewer systems. This study was conducted with two main drivers. The first was managing the wet-weather conditions to meet regulation, which are included in this IWWIP. The second driver was adequately managing its aging assets. Therefore, a methodology was used that would focus on creating short- and long-term reinvestment strategies for the wastewater collection, wastewater treatment, and water distribution systems. The results of this analysis included a determination of the adequacy of the current reinvestment rate and identification of additional assessment, repair, and replacement needs for the next five years and in five-year increments for the next 35 years.

Most of the water distribution and wastewater collection system assets were installed in the early twentieth century and have useful lives ranging from 50 to 100 years. Most of the wastewater treatment plant was built in the 1960s and has been expanded and modified over the years since. Keeping these assets in good working order is essential to providing public health and environmental benefit every single day. Assets performing as designed and supported by a fully implemented program of repair and replacement (R&R) will also benefit the IWWIP and compliance requirements.

The study considered each asset individually based on installation records, asset attributes, and condition reports (if available). For many assets, comprehensive condition assessment and attribute characteristics were not yet available.

The main output of the R&R study is the capital project schedule for each system (water distribution, wastewater collection, and wastewater treatment): year-by-year for the short-term capital improvements needed (2019-2023); and a capital program schedule for each system in five-year increments for the long-term capital improvement needs. The projects identified to meet long-term system needs are conceptual in nature, and all identified costs are planning-level estimates. TABLE 3-1 presents the recommendations of the R&R study; the full technical memorandum documenting the approach and methodology is included in Appendix 3-1.

TABLE 3-1. Summary of repair and replacement study recommendations ($ millions)

Asset Type	2018	2019	2020	2021	2022
Collection	0.99	1.98	2.98	2.98	2.98
WWTP	4.21	1.72	1.88	1.84	9.41
Water Distribution	1.89	2.27	2.72	3.27	3.92
Total	**$7.09**	**$5.97**	**$7.58**	**$8.09**	**$16.31**

Asset Type	2023 to 2027	2028 to 2032	2033 to 2037	2038 to 2042	2043 to 2047	2048 to 2052	2053 to 2057
Collection System	19.65	18.28	19.65	18.28	16.25	14.88	16.25
WWTP	6.67	6.76	3.79	13.86	4.92	7.51	3.67
Other	0.09	0.21	0.00	0.09	0.21	0.00	0.09
Water Distribution	19.6	19.6	19.6	19.6	19.6	19.6	19.6
Total	**$46.01**	**$44.85**	**$43.04**	**$51.83**	**$40.98**	**$41.99**	**$39.61**

3.5 HISTORICAL BILLS CONTINUE TO GROW RELATIVE TO INCOME

As enterprise funds, the water and wastewater systems must increase revenue to cover increased costs. The costs of operating the systems and making capital improvements to improve water delivery reliability, improve sanitary sewer performance, and reduce overflows have increased significantly over the past 10 years. Operating expenses for the wastewater fund have increased 7.5 percent per year between 1997 and 2017; operating expenses for the water fund increased 1.9

percent per year over the same time period.[8] This results in a blended 4.0 percent annual increase in system operating costs and that only tells a part of the story. The city has been making significant capital investments over the past ten years to improve system reliability and environmental compliance. The annual capital outlay and annual debt service costs for 1997 and 2017 are presented in FIGURE 3-15 below.

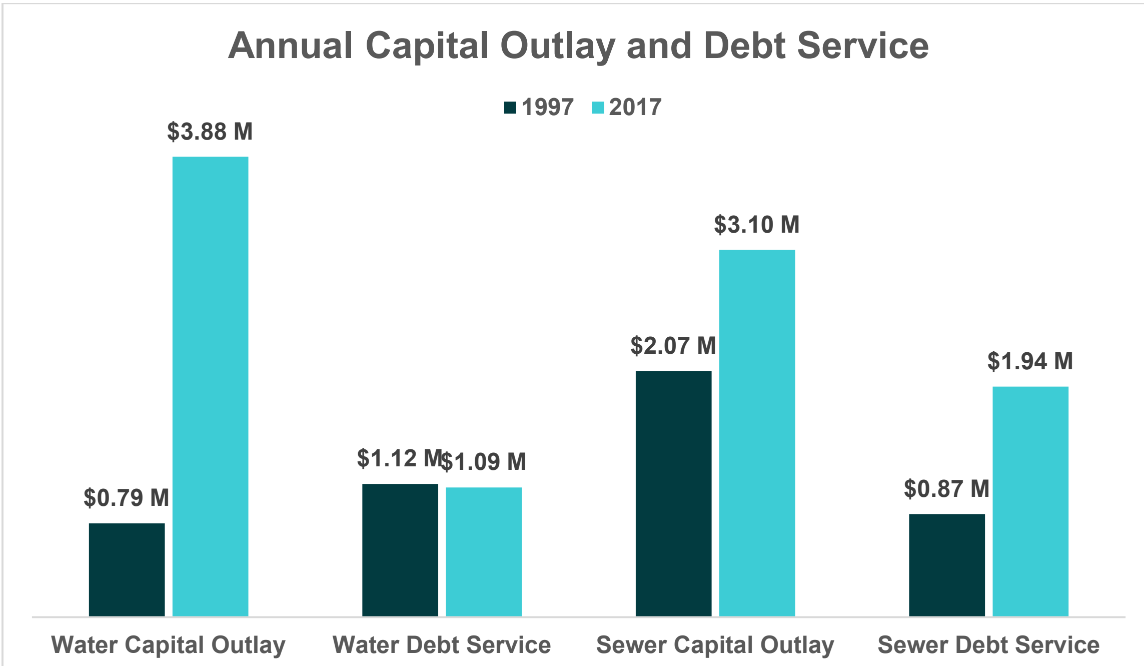


FIGURE 3-15. Historical Capital Investment Profile

The city's capital investments have resulted in annual sewer debt service that has doubled and annual capital outlays have increased by 143 percent since 1997. The increases in capital and operating costs, coupled with continued reduction in water sales, leads to rate increases to support the systems. The fear of "rate fatigue" is real.

The total water and wastewater bill increased from $29.76 in 1998 to $87.82 in 2019, an annual compounded annual growth rate of 5.8 percent. These increases have been directed more to the wastewater rates with an 8.1 percent annual growth rate versus the 4.2 percent annual growth rate for the water rates. These increases are even more striking when compared to the Ohio median real weekly income over the same time, a metric published by the St. Louis Federal Reserve Bank. Over the same period, median wages for full-time employees have stagnated resulting in a compound annual growth rate of only 0.3 percent.[9] This information is presented in FIGURE 3-17.

[8] Based on actual operating expenses as reported in the 1997 and 2017 Comprehensive Annual Financial Report on a non-GAAP basis, excluding capital outlay and debt service costs.

[9] Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org

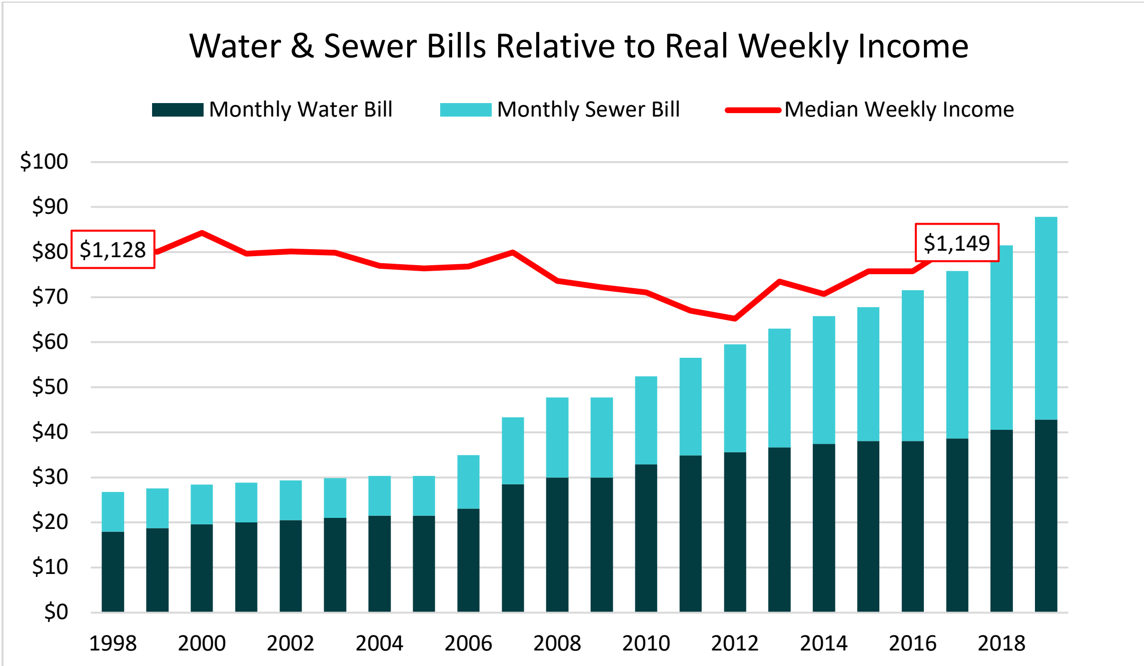


FIGURE 3-16. Historical water and sewer bills versus real weekly income

This data suggests that, on average, the portion of median weekly income dedicated to customer's water and sewer bills in Lakewood has tripled since 1998. Further, it shows the percentage of real weekly income dedicated to water and sewer service. This increase is particularly problematic for the low- and fixed-income population in Lakewood, who have had to make other sacrifices to afford water and sewer services. FIGURE 3-17 presents the amount of the median real income since 1998 that is required to pay a typical water and sewer bill. This graph considers the actual historical rates and charges and does not consider the long-term financial capability or affordability of the IWWIP and long-term asset management needs; additionally, FIGURE 3-17 is also based on the measure of real income which accounts for inflationary and cost of living factors.

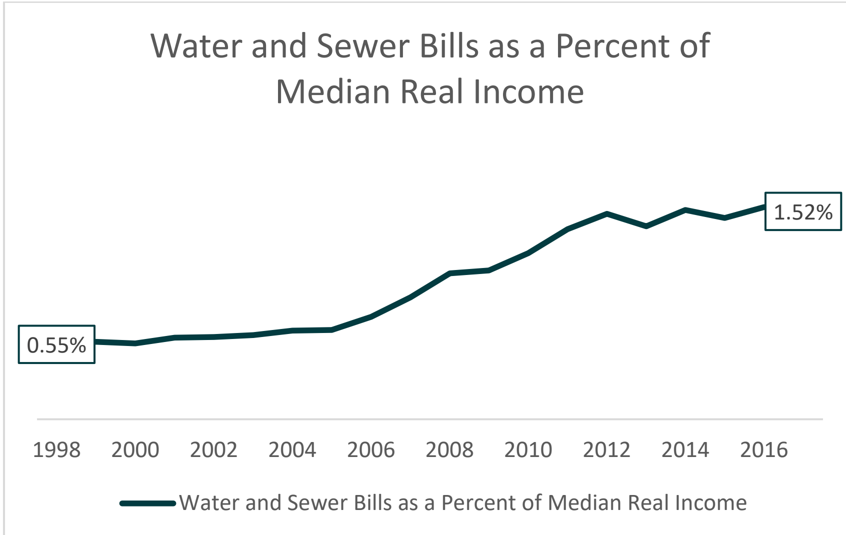


FIGURE 3-17. Water and sewer bills as percent of median real income

3.6 A Continuing Commitment

Because of the community commitment to environmental improvement, Lakewood City Council took an unprecedented action for Lakewood and approved a five-year program of future water and sewer rate increases in December 2018 that will become effective annually between 2019 and 2023. These rate increases support the ongoing progress and investment being made by Lakewood to support water and sewer and overflow reduction. The major capital improvement being supported by this rate increase is a more than $21 million investment in construction for a new HRT facility adjacent to the wastewater treatment plant. Construction of the HRT is scheduled to begin in 2019 and be completed by 2022. The city will also be continuing early action sewer separation, outfall repairs, miscellaneous sewer line repair and replacement, and manhole rehabilitation. Water rates will increase by 5.5 percent per year through 2023 and wastewater rates will increase by 10.0 percent per year through 2023. FIGURE 3-18 shows the typical combined water and sewer bill under this program of approved rates. Because of the analysis underlying this IWWIP, Lakewood had the confidence that this considerable commitment of limited community resources would result in the best environmental improvement for the money spent.

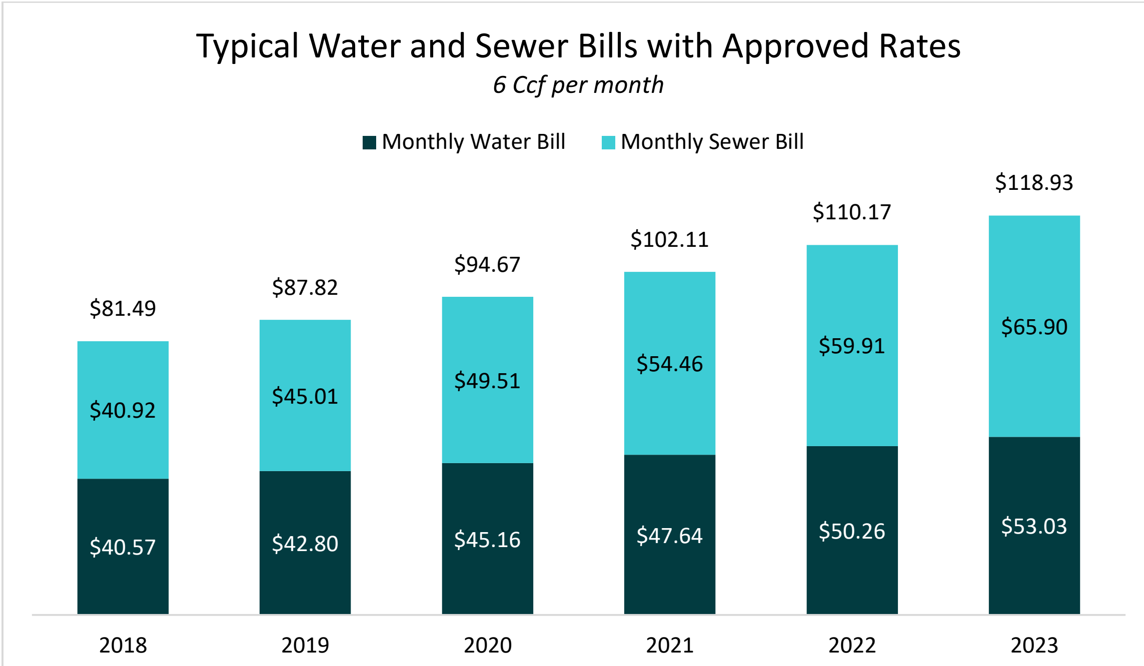


FIGURE 3-18. Typical monthly water and sewer bills with approved 2018-2023 rates

Lakewood City Council has made a strong commitment to preserving and enhancing environmental quality with this rate approval. These increases will support the existing obligations, the next few years of planned investment, and lay the groundwork for a continued progress under the IWWIP beyond the next five years.

Lakewood residents have endured significant rate increases in the costs of water and sewer since 1998 as demonstrated by FIGURE 3-17. The forthcoming increases represent another 7.85 percent per year average annual increase in water and sewer costs. When considered in totality, a typical customer bill of $26.76 in 1998 will increase by 6.1 percent per year through 2023 and result in a typical bill of $118.93.

Lakewood's fragile economic situation is why rate increases beyond 2023 must be moderated and closely aligned with cost of living adjustments. The rental and housing market are already enduring a shock by absorbing the new property tax re-appraisal impact along with these utility rate increases. An extended period of time for things to stabilize is essential to sustaining progress.

3.7 Lakewood is Competitive Regionally, But the Region is Extremely Challenged

Rehabilitating northeast Ohio infrastructure is a bigger challenge than in other regions of the country. Many other regional utilities are facing challenges similar to the city and the city's current water and sewer rates are comparable to other utilities in the region, FIGURE 3-19. National Public Radio (NPR) published on February 8, 2019 an article that highlights the growing water affordability crisis in many large Great Lakes cities.[10] Cleveland was mentioned throughout the article and the data presented shows the largest increase for Cleveland customers (109 percent since 2010). The research shows that, collectively, Great Lakes cities are under extra pressure to comply with environmental regulations and provide clean drinking water at an affordable price.

As shown in FIGURE 3-16 which demonstrated the increase in Lakewood rates since 1998, the city has been proactively addressing the operating and capital needs of the utilities for many years.

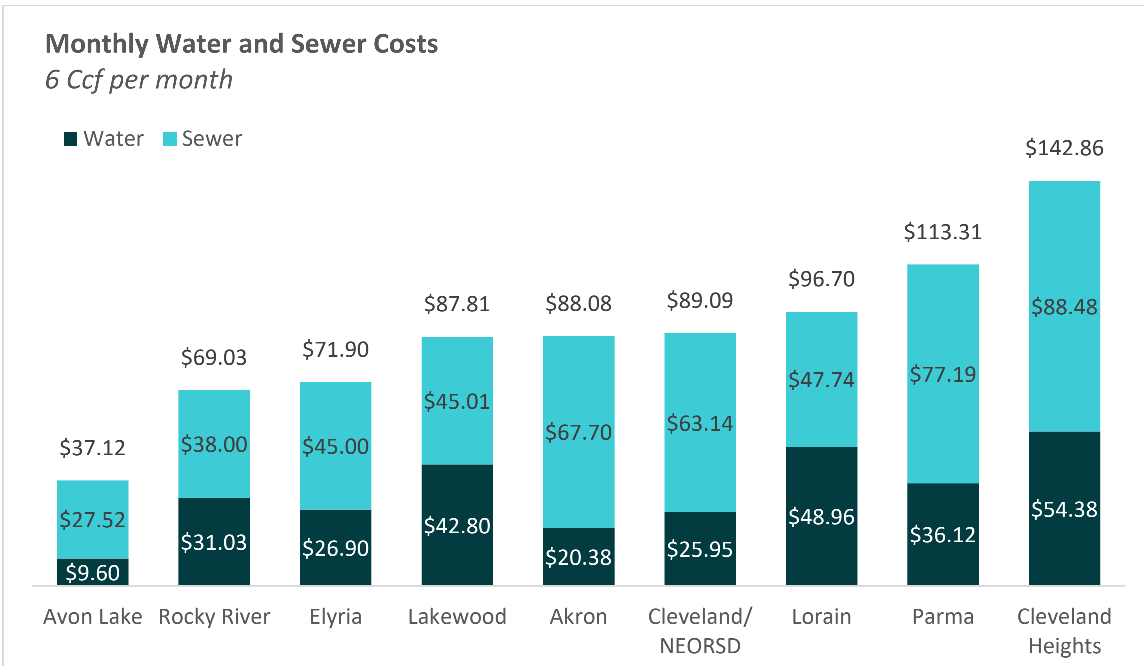


FIGURE 3-19. Water and sewer bill comparison

The population trends previously discussed show a movement towards the suburban and ex-urban communities and it is imperative that Lakewood retain its competitiveness in overall costs of living to combat this shift. After the end of the approved rate cycle in 2023, the city's combined water and sewer bill will be approximately $119. This level of customer bill may be projected to keep Lakewood in the center of this comparison group. However, any requirement to arbitrarily expedite spending additional community funds on sewer solutions where they have minimal incremental environmental impact will push the cost of sewer service and sewer rates to levels that will make Lakewood uncompetitive even among the struggling communities of northeast Ohio.

3.8 Lakewood Bills as a Percent of Income

[10] https://www.npr.org/2019/02/08/691409795/a-water-crisis-is-growing-in-a-place-youd-least-expect-it

A primary measure of affordability in the 1997 Financial Capability Assessment guidance is the household share of total control costs as a percent of annual MHI. As a corollary, many utilities examine the typical bill for water and sewer service as a percent of MHI. If more than 2 percent of MHI is required to pay the annual bill (per service), then the area is a high-burden area. FIGURE 3-20 shows the percent of the median monthly wastewater bill for customers living within each census tract at the current 2019 rates and usage level based on the city's 19 census tracts and specific data for their actual median water usage and tract-specific MHI.

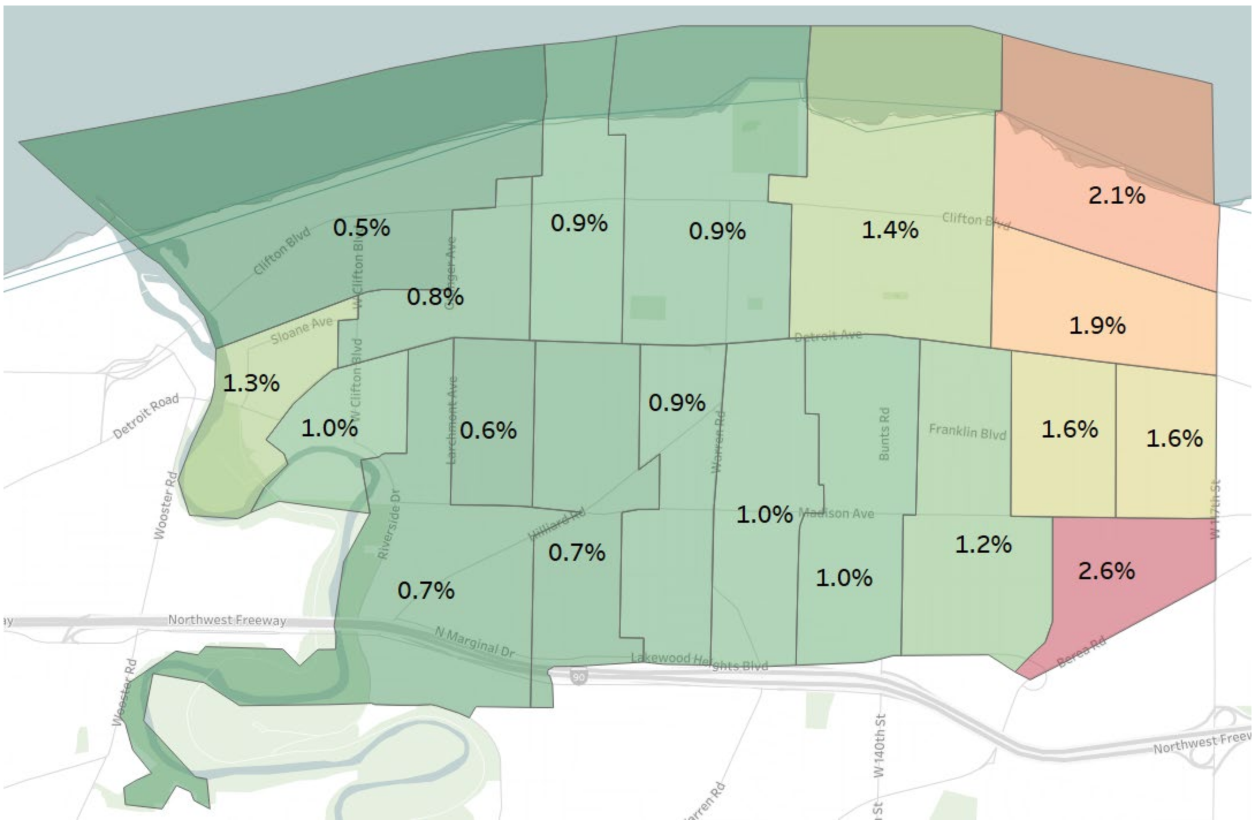


FIGURE 3-20. Current wastewater bills as a percent of census tract household income

FIGURE 3-20 reflects the current, 2019 wastewater rates and the most recently released census information for household income (the 2017 ACS). A table that considers the rates and charges after the approved five-year rate program (in 2023) is presented in FIGURE 3-21 below. This projection assumes 1.50 percent annual increase in median household incomes. Unless there is significant economic prosperity improvement to cause greater than 1.50 percent annual income growth within the next five years, the number of Lakewood census tracts whose monthly wastewater bills will exceed 2.0 percent of median income more than doubles.

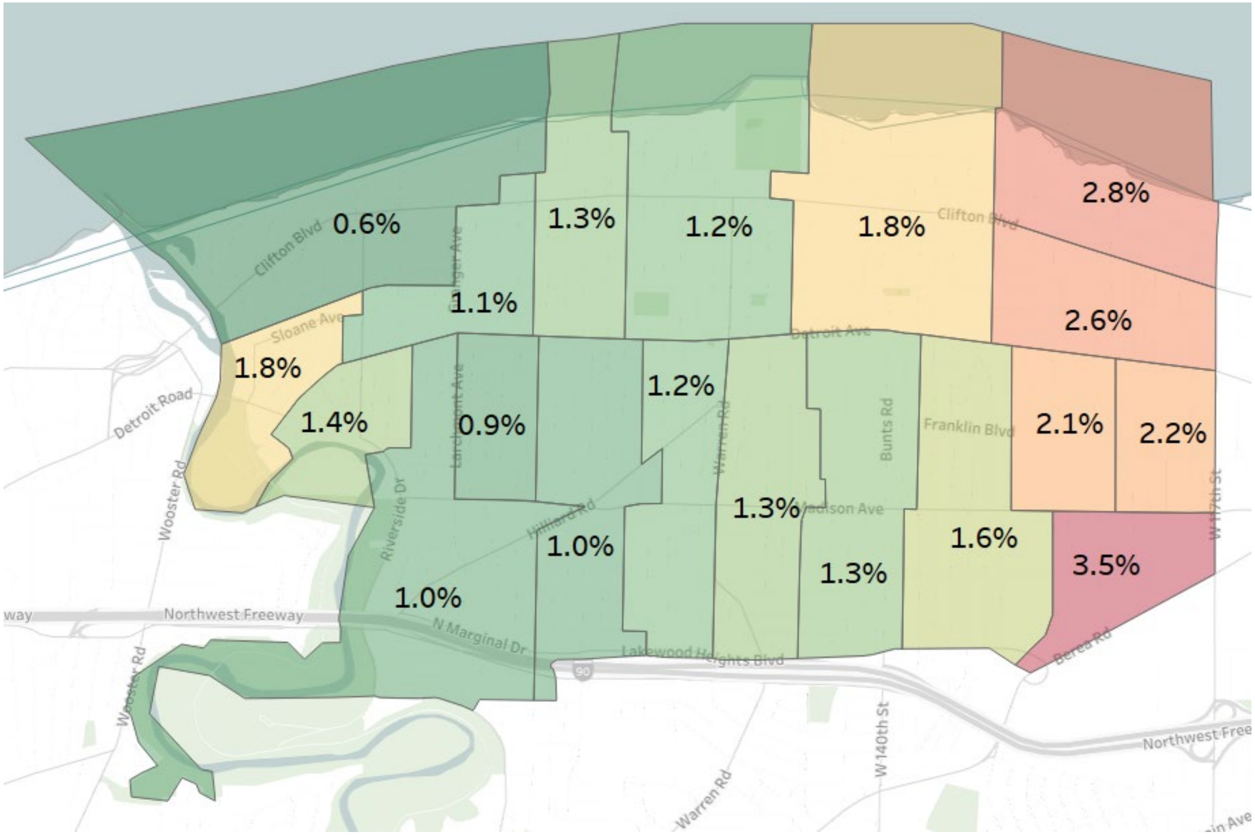


FIGURE 3-21. Projected 2023 wastewater bills as a percent of census tract household income

An additional affordability measure examines the number of hours worked at minimum wage to pay the monthly water and wastewater bill. At the current state minimum wage, a typical residential customer in Lakewood with monthly usage of 6 Ccf would need to work 11 hours to pay for his or her monthly bill. In 2023 after the approved rate program, it is projected to take 14 hours of work at minimum wage to afford the water and sewer bills (assumes 1.50 percent annual increase in minimum wage). There is no formal threshold established for a reasonable number of hours worked, but industry journal articles and academic research point to greater than 8 hours per month as high burden.

3.8.2 INCOME DISTRIBUTION BY QUINTILE

The projected affordability shown in FIGURE 3-20 and FIGURE 3-21 are based on the median household income for each census tract. One of the key weaknesses of the CSO Guidance for Financial Capability Assessment and Schedule Development published by the EPA in 1997 (1997 Guidance)—a weakness identified by the United States Conference of Mayors, the National Association for Clean Water Agencies (NACWA) and the Water Environment Federation—is that the median is a poor statistical measure for measuring the financial capability and affordability of a proposed capital program. The median does not account for the bottom 49 percent of all community households by definition and is only a valid measure with a dataset of very narrow distribution.

In recognition of the median's inability to measure affordability, one of the additional datasets to be explored that is identified in the EPA Integrated Planning Financial Capability Assessment Framework that was released in November 2014 is income distribution, including income quintiles. A quintile is another word for income at multiples of the twentieth percentile (i.e. 20th, 40th, 60th, 80th and 100th). The median value represents the center value for a population and splits the data into two segments—above 50 percent and below 50 percent. Quintiles similarly split data into segments, but rather than making up 50 percent of the population, they represent one fifth or 20 percent of all observations within a population or a dataset.

Dividing service area households into only two groups based on median income obscures the impact of rising utility costs on customers with income below the median level who face the greatest affordability challenges. For Lakewood, this could obscure the impacts on approximately 27,000 people. The evaluation presents more severe affordability concerns if we substitute the first or second quintile, representing households reporting in the lowest 40 percent of income in the census blocks within the service area. Based on census data, Lakewood households in the second quintile have annual household income of $37,817 or less. This is nearly 20 percent less than the citywide MHI of $47,145 from the same period.

Analyzing the impact of proposed rate increases for customers in the first two quintiles results in annual sewer utility costs crossing the 2 percent affordability threshold as much as nine years sooner than when compared to the median household income. Annual wastewater service costs are projected to cross the 2 percent affordability threshold in 2026 for the households in the second quintile versus 2035 for households using the MHI method.

An analysis of the typical customer bill based on actual consumption levels and the approved rates through 2023 for households at the 40th income percentile is presented in FIGURE 3-22. The projected bill as a percent of income for households at the 20th percentile is presented in FIGURE 3-23. **Within five years the approved rate increases that are funding necessary asset management and the initial IWWIP projects will push the typical customer bills above the 2 percent high burden threshold for a great number of Lakewood households. Many economically depressed households that are in the first 20th percentile of income will face severe burden exceeding 8 percent of income.**

These results are another key reason why Lakewood must have the flexibility to gradually manage the pace of improvements to protect the large population of at-risk residents.

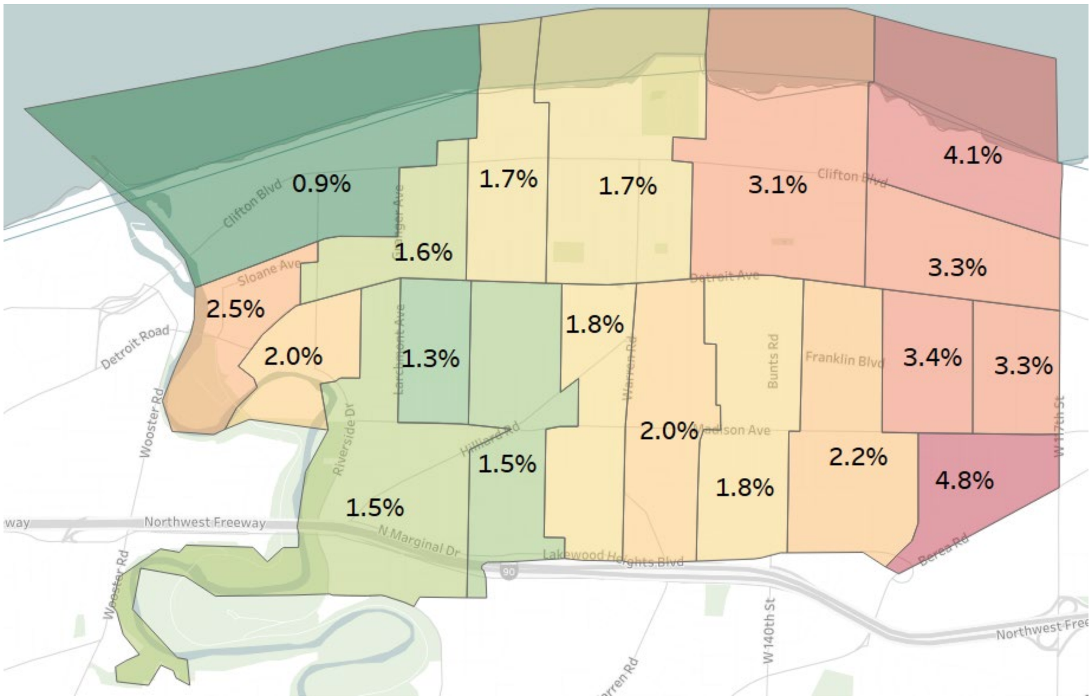


FIGURE 3-22. Projected 2023 wastewater bills as a percent of census tract 40th percentile income (2nd quintile)

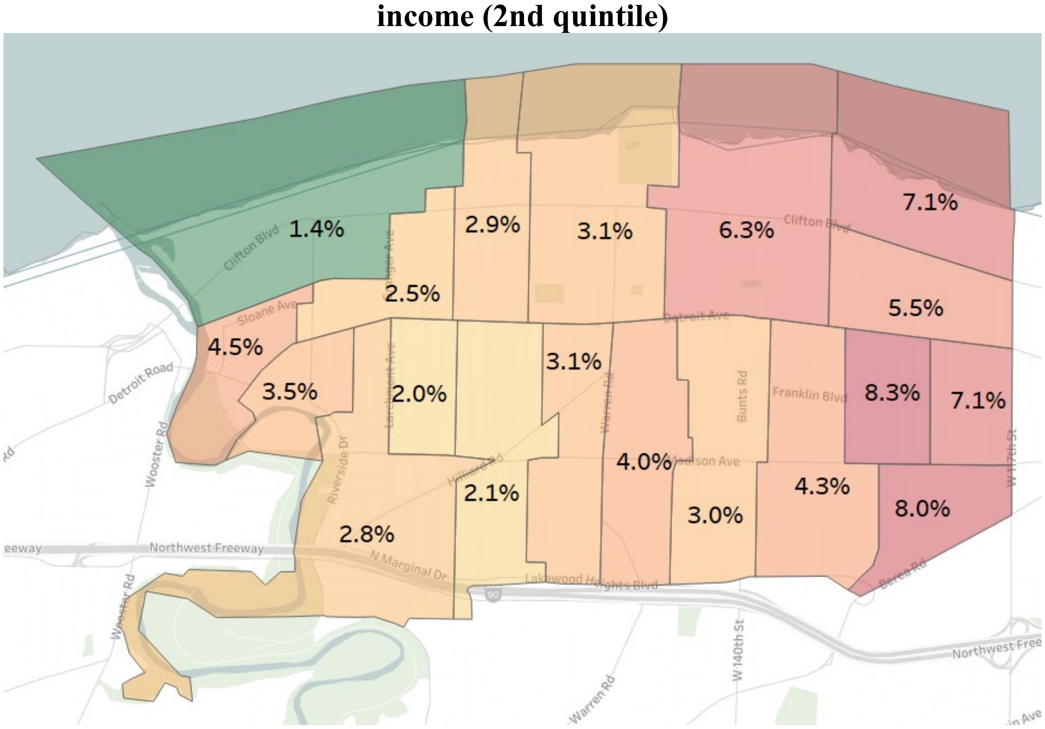


FIGURE 3-23. Projected 2023 wastewater bills as a percent of census tract 20th percentile income (1st quintile)

FIGURE 3-22 and FIGURE 3-23 demonstrate that there is a significant portion of Lakewood customers who will feel a high burden in affording water and sewer service shortly after the currently approved rate increase program. The IWWIP is committed to delivering solutions that balance household affordability with the pace of capital investments. As soon as 2023, the city will have a large portion of households with potential to feel a high burden in paying for water and sewer service. The city currently offers Homestead and Senior Citizen programs that provides an approximate 35 percent reduction in customer bills to assist households that have a demonstrable need. As the costs of water and sewer service expand, the city is committed to providing customer assistance programs that meet the needs of their customers. This may include expansion of the programs offered.

3.8.3 Demographics Show a Balanced Population

There are other demographic and economic indicators that should be considered when evaluating the financial capability and customer affordability relative to Lakewood's IWWIP.

FIGURE 3-24 shows the percentage of households receiving retirement income, disability income, households with residence aged 60-plus, and households participating in the Supplemental Nutrition Assistance Program (SNAP). With the exception of pockets of significant wealth and poverty, the number of households with limited and fixed income is distributed across every neighborhood within Lakewood. These maps show that the fabric of the community is spread with relative uniformity and that poverty is relatively uniformly present across Lakewood.

These data illustrate that no single customer group can be expected to contribute more than others to increase the magnitude or pace of the capital program. The community has a willingness to make environmental improvements with the pace and scale that can be reasonably supported by all members of the community.

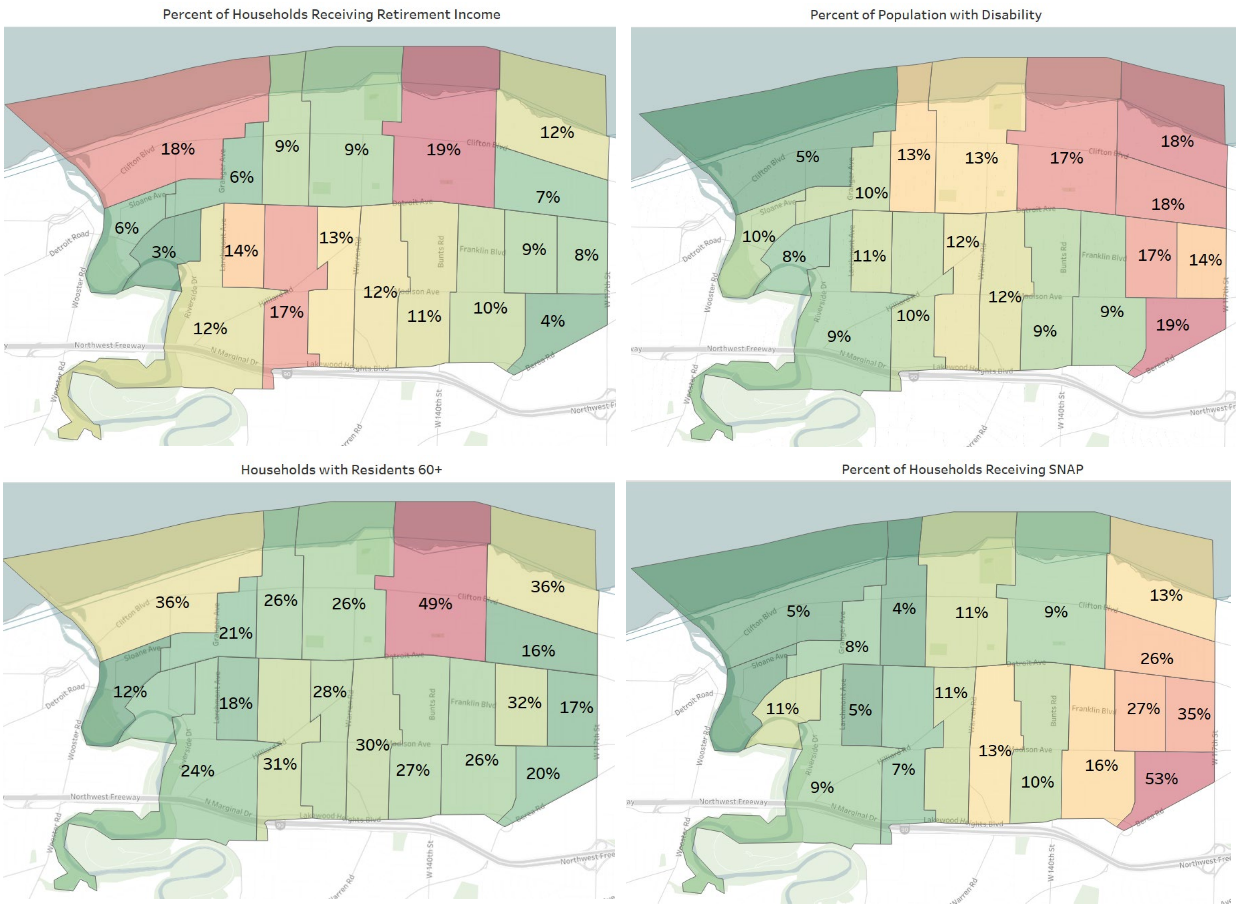


FIGURE 3-24. Lakewood demographic indicators

3.8.4 FINANCIAL CAPABILITY ASSESSMENT SUMMARY

The 1997 Guidance provided a framework for utilities to evaluate their ability to finance capital improvements related to CSO consent orders. The document builds off previous EPA publications and indicates that, for regulatory and compliance scheduling purposes, financial capability can be assessed with a two-phase evaluation of a municipality. The first phase determines the Residential Indicator (RI) and the second phase is an assessment of six additional parameters indicative of overall financial strength of the community.

Additionally, in May of 2012 EPA published guidelines for the Integrated Municipal Stormwater and Wastewater Planning Approach Framework that promote integrated approaches to meet CWA obligations. As a follow-up to the continued development of Integrated Planning Framework, EPA published additional guidelines to Financial Capability Assessment Framework in November 2014 which established several key elements to EPA's approach to financial capability evaluation. This chapter includes additional information that is identified in the November 2014 Framework to present a comprehensive assessment of the city's financial capability.

The complete calculations and work product of the 1997 Guidance is included in Appendix 3-2. The result of the 1997 Guidance analysis shows Lakewood faces a high burden to complete the IWWIP. The total estimated cost of the IWWIP is \$177 million (including the design and construction of the HRT facility currently scheduled to begin construction in 2019) and the total estimated cost of delivering a rehabilitation and renewal program for the existing sewer assets is \$162 million over the same time period. Based on this total investment liability of \$339 million shared across 24,500 households, the RI using the 1997 Guidance approach is 2.71 percent. This exceeds the 2.0 percent threshold for a high burden household by 35 percent.

The city's permittee score is an average of six metrics based on common financial data. Overall net debt as a percent of full market value of property, the unemployment rate, median household income, and the property tax collection rate are all mid-range indicators. The city's bond rating of "Aa2" and its tax revenue as a percent of full market value, 1.73 percent, are both considered strong indicators. In total, Lakewood has a permittee score of 2.3.

When these results are plotted on the Financial Capability Matrix, we can see that Lakewood faces a high burden to make the necessary improvements to its sewer system. See FIGURE 3-25.

			Residential Indicator (Cost per Household as a % on MHI)		
			Low (Below 1.0%)	Mid-Range (1.0% to 2.0%)	High (Above 2.0%)
			0.0%	1.0%	2.0%
Permittee Financial Capability Indicator	Weak (Below 1.5)	0.0	Medium Burden	High Burden	High Burden
	Mid-Range (1.5 to 2.5)	1.5	Low Burden	Medium Burden	High Burden **RI: 2.71%** **PI: 2.3**
	Strong (Above 2.5)	2.5	Low Burden	Low Burden	Medium Burden

FIGURE 3-25. City of Lakewood 1997 Guidance financial capability result

3.9 SEWER FINANCIAL PLAN AND RATE STUDY

The 1997 Guidance offers only a limited point-in-time analysis of the financial capability of a utility and its customers. Its limitations and drawback, especially in not accounting for trends, are well-known. The city, however, has prepared a supplemental financial plan that considers the impact of potential capital improvement needs over time and in relation to the operational and financial policy considerations it must make when managing the systems. The financial plan was developed as a long-term decision support tool and is based on the most recently available customer, cost, and capital needs information with the final result being an indication of the rate adjustments needed to provide revenues to support the systems.

Developing a financial plan is essentially solving for a formula that aims to balance revenues with expenditures over a planning horizon. Revenue is primarily generated from user rates and charges through quarterly customer bills. The projection of revenues is based on the same assumed customer accounts and billable water/sewer volumes with variations for proposed rates and charges in future years. Expenditures include operating costs, existing and future debt service, cash-financed capital expenses and fiscal management considerations such as reserve contributions and debt service coverage requirements.

The financial plan expenditures are based on the current 2019 operating budget that is projected based on inflationary cost increases in the future, existing debt service and proposed debt service needed to fund the capital improvement needs of the system, and rate-funded capital expenses (PayGo Capital). Additionally, as enterprise funds of Lakewood, the water and wastewater utilities must maintain a healthy fiscal position by maintaining cash reserves and debt service coverage, limiting fluctuations in annual rate increases, and limiting their exposure to long-term debt obligations (as compared to system assets).

Implementation of this IWWIP is anticipated to be completed in five-year commitments associated with NPDES permit renewals that will reference the next activities associated with the IWWIP. At this time, five project bundles have been identified that are anticipated to coincide with sub-sequent future permit terms. These bundles are described in detail in Chapter 8. The city has approved rate increases through 2023 that will support an average of approximately $5 million per year toward IWWIP implementation through 2033. As demonstrated earlier in this chapter, the implementation of the IWWIP will be subject to the future affordability limits applicable to the city.

Additional capital is included in the sewer financial plan for the necessary and ongoing repair and rehabilitation (R&R) funding. The city's water and sewer systems are old with many assets nearing the 100-year-old mark. The water and sewer mains, pump and lift stations, and existing wastewater treatment plant all require consistent investment to be maintained in good working condition. An analysis was completed that evaluated the installation dates and useful lives of assets in service throughout the city to develop a long-term R&R cost estimate.

On average, the recommendations call for approximately $5 million in annual funding of wastewater system assets for necessary R&R projects. The water system maintenance projects require approximately $3 million annually. The full details of this analysis can be found in the technical memorandum that is included in the appendix. The city will continue to analyze projects and look for opportunities to leverage the R&R investment to be used toward these IWWIP projects that involve rebuilding the existing sewer system

3.9.1 Projection of Operating Costs

Water and sewer operating costs are projected based on the 2019 adopted budget and escalated by factors reviewed and approved by Lakewood staff. The escalation factors vary by account type, and the overall annual rate of operating cost increase is 3.0 percent for water and sewer.

Additionally, certain incremental operating cost increases have been added where they are known and account for increases in purchased water costs, additional positions, and state revolving fee costs.

The cost of purchasing potable water from Cleveland is the largest water expense and increases in those charges are beyond the Lakewood's control. The financial plan assumes about a 3.2 percent annual increases in the purchased water costs. Costs associated with operating and maintaining the wastewater treatment plant accounts for most of the sewer operating costs. At this time, no large, incremental operating costs are anticipated as a result of the IWWIP projects with the assumption that any cost increases will be absorbed within the annual 3.2 percent increase.

3.9.2 Debt Service Requirements

The city has already made significant capital investments, particularly to the sewer system, as it began to undertake projects to improve and optimize its operation and efficiency. These capital investments have been funded with a mixture of cash and long-term borrowing, primarily through the issuance of general obligation bonds as well as loans from the Ohio Public Works Commission and Ohio Water Development Authority.

Because the city purchases potable water from the Cleveland Water Department and does not have its own water treatment facilities, the water utility has not made as much capital investment as the wastewater system. The network of water mains are reaching the end of their useful lives and the capital improvements plan includes a number of watermain replacement projects. Many of these initial projects are currently underway or are in the final stages of design. The need for continued investment in existing century-old water infrastructure will increase as the age of these assets increases.

3.9.3 Capital Improvement Needs

The city has made significant capital investments in its wastewater system to sustain its progress and achieve high pollutant control. Lakewood has awarded a contract to construct a $21 million high-rate treatment facility adjacent to its wastewater treatment plant that will be able to capture an additional 3 percent of storm runoff. Further investment is planned to reduce system overflows and improve system reliability to address Lakewood's aging infrastructure.

Chapter 8 describes the projects proposed with this IWWIP and has a total estimated cost of $150 million (excluding the $21 million HRT facility). The capital improvements also include funding of the necessary R&R projects of existing infrastructure at an average annual rate of approximately $5 million per year. FIGURE 3-26 shows the currently projected timing of capital delivery for the HRT, IWWIP, and R&R program.

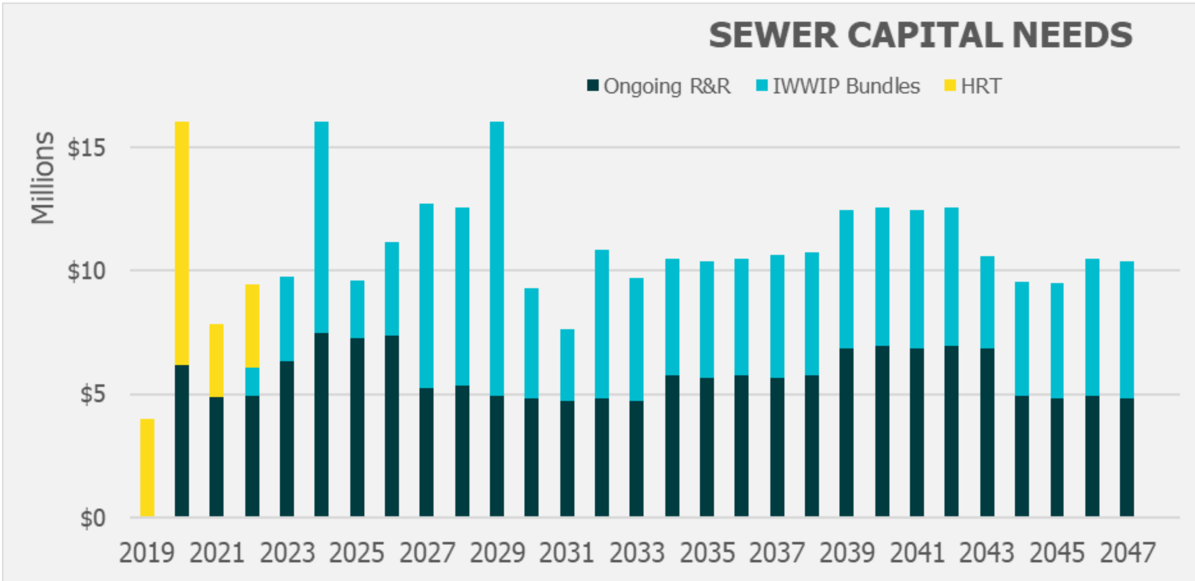


FIGURE 3-26. Sewer system capital needs

3.9.4 Revenues

The majority of annual revenues that the city's water and sewer funds generate are from user rates and charges that individual customers pay for the service they receive. These revenues are based on the volumetric rates assessed by the city based on metered water usage. Given the projection of usage which includes an assumption of 1.0 percent reduction in water sales per year (in keeping with the trend presented in FIGURE 3-14), a calculation of the revenue to be expected under the existing rates was made as baseline.

Rate increases are needed to fund the operational and capital requirements of the city. The increases are primarily driven by capital needs that have immediate costs over the next few years, primarily the HRT and R&R work, and continue indefinitely. It is obvious that the city cannot significantly increase customer rates in a single year to provide funding for the full capital needs of the IWWIP and R&R programs. The approved rate plan for 2019-2023 serves as a foundational adjustment to support the current commitments and then a gradual and consistent increase is projected to allow for funding of the future system needs.

The approved rates through 2023 include 10 percent annual sewer rate increases and 5.5 percent annual water rate increases. Beyond 2023, one financial plan projects 4 percent annual rate increases to both utilities that will support operational and capital investment needs. FIGURE 3-14 demonstrates the inherent volatility of the city's revenue structure that is currently based strictly on water sales. The city asked residents during the stakeholder engagement activities described in Chapter 9 about implementing fixed charges to supplement the volumetric charges. There was strong customer support for the implementation of a fixed monthly charge as well as an impervious area-based charge.

The fixed service or base charge could be assessed to all customers regardless of water consumption and recover the administrative costs of billing and collections, customer service, and potentially a portion of fixed capital costs. The introduction of a fixed revenue stream would help stabilize revenues and lessen the degree to which declining water sales will influence the financial plan. This charge will be analyzed over the coming months and implemented once the appropriate community outreach and understanding can be provided.

Lakewood intends to explore additional methods of charging for service that will improve system equity and revenue stability. Specifically, an impervious-area-based charge assessed to each parcel would help stabilize revenue that is currently impacted by declining water consumption. This type of fee structure also aligns well with a program designed to mitigate the impacts of storm runoff.

Some of the *conceptual elements* of a fee structure that could be explored and further refined *may* include:

- All parcels in the city charged fixed wet-weather fee based on impervious area.
- In non-single-pipe areas, lateral P-traps on storm or sanitary are declared nuisance and require replacement with installation of a test-tee.
- Credit available to properties in separated areas that certify (a) there is no storm water entering sanitary, (b) no lateral P-trap exists and (c) test-tees are installed.
- Stormwater certification above may be time-limited depending on lateral construction and material type.
- Proportional residential credits available for BMPs (for rain barrels and gardens and other green infrastructure; requires periodic certification).
- Commercial credit available for BMPs that *exceed* city code requirements applicable to new construction.

The city has learned a number of lessons from the pilot project and these will be used in the conceptual development and implementation of any impervious-based fee structure. For instance, private property connections have been found with widely-ranging conditions, ease of accessibility, and repair requirements. The pilot program is discussed in greater detail in Chapter 5. These differences need to be considered such that a new fee is affordable and equitable for all residents.

3.9.5 Financial Plan Projections

A wastewater financial plan is presented in FIGURE 3-27 and shows how the currently approved rate plan provides funding needed to support the capital outlay of the HRT and system R&R through 2023. The revenues are projected to increase by approximately 3.0 percent per year beyond 2023 based on 1.0 percent reduction in water sales and 4.0 percent annual rate increases. Household affordability is a major point of emphasis throughout this plan and is based on the total service costs incurred by each customer. A rate structure changes described conceptually in this chapter to implement a fixed charge and impervious-area based charge could be developed to be revenue neutral to this plan. Under this projection, wastewater bills for the typical customer using 6 Ccf of water per month would exceed the projected median household income of the city in 2035. At this time, the plan would stop future rate increases until incomes increase to support additional changes.

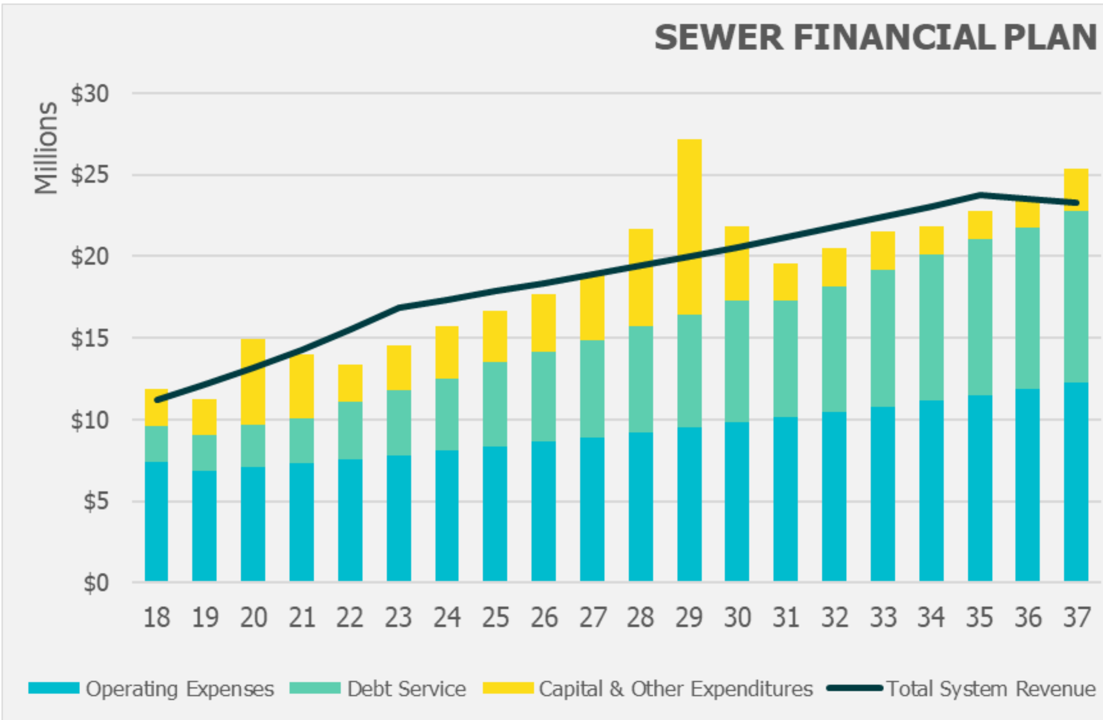


FIGURE 3-27. Conceptual wastewater financial plan

This capital plan is projected to be funded with a mixture of long-term debt and cash. At the end of the current rate plan in 2023, annual debt service requirements would be projected to be nearly 80 percent larger than the 2019 budget. By 2028, a 193 percent increase in annual debt service requirements is forecast and this increases to a 275 percent increase by 2033. On an annual basis, the city's wastewater debt service requirements for principal and interest payments will increase by 9.9 percent per year.

3.9.6 Financial Policy Requirements

As enterprise funds, the city has policy goals for maintaining certain levels of operating and capital reserves to maintain the solvency and credit-worthiness of the funds. These cash reserves act as working capital to balance cash flows with ongoing costs of operating the systems, emergency reserves for capital needs, and reassurance to creditors that helps strengthen the city's overall credit rating and allows it to borrow money at lower rates. The magnitude of the city's capital plan will require significant future borrowing. This financial plan targets an operating reserve balance of 180 days of annual O&M costs which is consistent with rating agency guidance. Additionally, cash reserves are used to fund projects which often requires a building of reserves for several years to be spent on large capital projects in subsequent years.

In addition to cash reserves, maintaining healthy debt service coverage ratios is important when borrowing money, especially bonds. Debt service coverage refers to the cushion available once annual revenues are used to pay operating costs and before making debt service coverage payments. Having higher coverage provides a utility's creditors with assurance that even if unexpected operational issues occur, the utility will have sufficient revenue to repay its obligations as planned. This financial plan assumes an all-in debt coverage target of 120 percent. These coverage ratios are easily maintained throughout the early years of the forecast; however, this performance gradually declines as more debt is issued to fund the capital program.

These target balances and coverage ratios are used when establishing future rates but are not a fixed requirement solely driving any rate increase. Rather, they are taken together with the overall operational and capital needs to develop a stable financial plan that achieves the targets over many years. The performance of the wastewater fund relative to their targets are presented below (Figure 3-28).

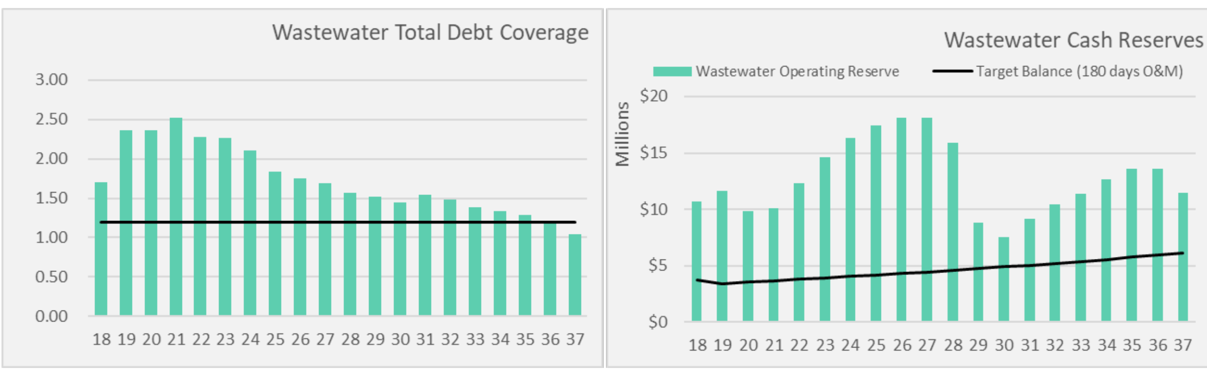


FIGURE 3-28. Wastewater financial metrics

3.9.7 Conceptual Financial Plan Affordability Implications

This financial plan that supports the IWWIP indicates serious affordability challenges for most customers within 15 years. A customer with income in the lowest 20th percentile of Lakewood households already faces a high burden at the prospect of paying a 6 Ccf sewer bill. Customers with income in the second quintile will face a high burden bill beginning in 2026. Customers at the median household income will face a high burden bill in less than 20 years, projected to cross the threshold in 2035 (Figure 3-29).

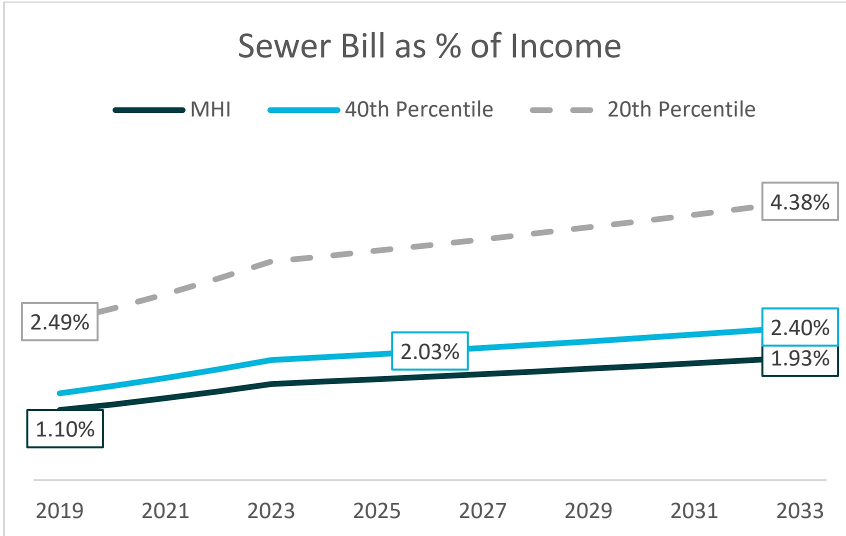


FIGURE 3-29. Sewer bills as percent of income percentiles through 2033

The average quantity used by Lakewood customers is 6 Ccf of water consumption per month. However, customer behavior varies greatly and assigning a 6 Ccf bill to all customers is merely a proxy. The following matrices were developed to help explore a broader spectrum of water and sewer affordability (Figure 3-30). Each matrix presents the percent of income a combined water and sewer bill of varying usage level (indicated across the top in each column header) would represent to each income quintile. Matrices are presented for 2019, 2023, 2028, and 2033.

One thing to note is the potential high burden faced by large households in the city. A large household that uses 10 or 15 Ccf of water per month would face high burden up to even the 80th income percentile in 2033. Furthermore, at the current rates a larger household at the 40th income percentile that uses 10 Ccf of water per month would face a total bill that equates to 4.4 percent of their annual income.

City-wide Household Income	2019 Value	Annual Bill as a Percentage of Household Income 100 Cubic Feet (Ccf) monthly water use							
		0	2	4	6	8	10	15	20
20th Percentile	$ 21,574	0.0%	1.6%	3.3%	4.9%	6.5%	8.1%	12.2%	16.3%
40th Percentile	$ 39,865	0.0%	0.9%	1.8%	2.6%	3.5%	4.4%	6.6%	8.8%
Median	$ 49,601	0.0%	0.7%	1.4%	2.1%	2.8%	3.5%	5.3%	7.1%
60th Percentile	$ 60,844	0.0%	0.6%	1.2%	1.7%	2.3%	2.9%	4.3%	5.8%
80th Percentile	$ 98,035	0.0%	0.4%	0.7%	1.1%	1.4%	1.8%	2.7%	3.6%

City-wide Household Income	2023 Value	Annual Bill as a Percentage of Household Income 100 Cubic Feet (Ccf) monthly water use							
		0	2	4	6	8	10	15	20
20th Percentile	$ 22,898	0.0%	2.1%	4.2%	6.2%	8.3%	10.4%	15.6%	20.8%
40th Percentile	$ 42,311	0.0%	1.1%	2.2%	3.4%	4.5%	5.6%	8.4%	11.2%
Median	$ 52,644	0.0%	0.9%	1.8%	2.7%	3.6%	4.5%	6.8%	9.0%
60th Percentile	$ 64,578	0.0%	0.7%	1.5%	2.2%	2.9%	3.7%	5.5%	7.4%
80th Percentile	$104,051	0.0%	0.5%	0.9%	1.4%	1.8%	2.3%	3.4%	4.6%

City-wide Household Income	2028 Value	Annual Bill as a Percentage of Household Income 100 Cubic Feet (Ccf) monthly water use							
		0	2	4	6	8	10	15	20
20th Percentile	$ 24,667	0.0%	2.3%	4.7%	7.0%	9.4%	11.7%	17.6%	23.5%
40th Percentile	$ 45,581	0.0%	1.3%	2.5%	3.8%	5.1%	6.3%	9.5%	12.7%
Median	$ 56,713	0.0%	1.0%	2.0%	3.1%	4.1%	5.1%	7.7%	10.2%
60th Percentile	$ 69,569	0.0%	0.8%	1.7%	2.5%	3.3%	4.2%	6.2%	8.3%
80th Percentile	$112,092	0.0%	0.5%	1.0%	1.5%	2.1%	2.6%	3.9%	5.2%

City-wide Household Income	2033 Value	Annual Bill as a Percentage of Household Income 100 Cubic Feet (Ccf) monthly water use							
		0	2	4	6	8	10	15	20
20th Percentile	$ 26,574	0.0%	2.6%	5.3%	7.9%	10.6%	13.2%	19.9%	26.5%
40th Percentile	$ 49,104	0.0%	1.4%	2.9%	4.3%	5.7%	7.2%	10.8%	14.3%
Median	$ 61,096	0.0%	1.2%	2.3%	3.5%	4.6%	5.8%	8.6%	11.5%
60th Percentile	$ 74,945	0.0%	0.9%	1.9%	2.8%	3.8%	4.7%	7.0%	9.4%
80th Percentile	$120,755	0.0%	0.6%	1.2%	1.7%	2.3%	2.9%	4.4%	5.8%

FIGURE 3-30. Total bills as percent of income percentiles through 2033, multiple consumption

The IWWIP represents the culmination of 5-plus years of analysis, evaluation, and contemplation all aimed to make considerable capital improvements to the city's wastewater system that will have tremendous environmental benefit. These improvements cannot come at the expense of continued maintenance of the existing system and the other priorities identified throughout this report.

The approved five-year rate plan supports the HRT construction that will begin in 2019 and the requisite R&R projects to address aging infrastructure issues. Making five-year commitments to continue the analysis and evaluation that will steer future investments to the most cost-effective solutions and allow for slow and gradual rate increases is the prudent option.

CHAPTER 4 – REGULATORY OVERVIEW

4.1 Introduction: Adaptive Management Flexibility is the Key to Continuing Progress and Achieving Compliance

The purpose of this Integrated Wet Weather Improvement Plan is to guide Lakewood's continued infrastructure and resiliency improvement, consistent with the city's Community Vision and with Clean Water Act Integrated Planning, to affordably achieve the city's articulated goals.

This IWWIP confronts the challenge of modernizing Lakewood's unique system, even where the system today performs well. Lakewood's system today removes a very high percentage of pollutants from the environment—much more than will be achieved by many communities after they eventually *complete* their long-term control plans and consent decrees under the CSO control policy. Lakewood has eliminated all identified dry-weather illicit discharges.

What Lakewood faces is a long-term enterprise, in part going comprehensively street-by-street and even house-by-house to create a 21st-century system. Building for Lakewood's second century has been a fundamental focus of the city administration, and that includes public and private property investment and renewal. But to sustain those necessary efforts, embraced by Lakewood and its citizens, they must be undertaken without tearing up the economy, vibrancy and very fabric of the community. To rush improvements will make them unsustainable, and progress will become unaffordable.

This IWWIP is necessarily premised on the concept of Adaptive Management, which reflects the flexibility in the Clean Water Act that will enable Lakewood to sustain progress, achieve its community goals and achieve the goals of the act. Adaptive management is a common-sense approach for achieving environmental and public health improvement, which is why it is a central guiding principle of the Ohio Domestic Action Plan for addressing the problem of Harmful Algal Blooms in Lake Erie. From the State of Ohio Domestic Action Plan 1.1 (August 2018 at p. 2):

> The [State of Ohio Domestic Action Plan] is not a static document. It is intended to be a plan that is subject to change and revisions following the Adaptive Management philosophy. As defined by the U.S. Department of the Interior "An adaptive approach involves exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions."

The flexibility of Adaptive Management that is fundamental to Integrated Planning is the key to Lakewood's success. Congress has now affirmed its centrality in the Clean Water Act.

4.2 MUNICIPAL INTEGRATED PLANNING IS CODIFIED IN THE CLEAN WATER ACT

4.2.1 2018 WATER INFRASTRUCTURE IMPROVEMENT ACT

On January 14, 2019, the President executed H.R. 7279, the Water Infrastructure Improvement Act (WIIA). The WIIA legislation amends the CWA in multiple ways that are highly relevant to Lakewood's IWWIP.

Congress Passes Integrated Planning into Law.
WIIA adds new Section 402(s) to the CWA. 33 USC §1342(s). First, this new section defines "Integrated Plans" in the statute as "a plan developed in accordance with the Integrated Municipal Stormwater and Wastewater Planning Approach Framework, issued by the Environmental Protection Agency and dated June 5, 2012." Lakewood's IWWIP has been developed pursuant to this same June 5, 2012 Integrated Planning Framework document, which is a requirement specified in Lakewood's 2014 NPDES permit.

Second, new Section 402(s)(3) of the CWA provides that Integrated Plans may be incorporated into a permit under this section, and that such Integrated Plans can address combined sewer overflows, CMOM programs, municipal stormwater discharges and municipal wastewater discharges. Lakewood's IWWIP addresses all of these.

Third, Section 402(s)(4) provides that compliance schedules to implement an Integrated Plan may be implemented over more than one permit term. The control measures in Lakewood's IWWIP implementation will require more than one five-year permit term, and the IWWIP provides timely progress reporting with a full pipeline of ready projects.

A schedule of compliance in Lakewood's five-year NPDES permit cycle is the most appropriate enforcement mechanism for Lakewood's IWWIP that will achieve improvement as soon as possible. Priority projects are identified, and the highest priority project would be on land already owned by the city. But most others measures are much more complex. The fact that Lakewood has been an extremely dense, fully built-out city for more than a century means that there is no readily available land for new facilities. Lakewood has demonstrated that it is able to be, and must remain, highly nimble to respond to land use changes when they occur.

Lakewood's unique collection system requires a careful, iterative street-by-street analysis so that renewal work can be properly sequenced and not to create any increased risk of basement backups. Lakewood's affordability limitations demand that all collection system work must be timed with other infrastructure work, such as comprehensive street rebuilding and water line replacements. These unique local conditions mean that Lakewood has a long forecast of work that can be planned, but that it must remain flexible with its limited funds to leverage new land use opportunities as they arise, some of which occur only once a century, and must coordinate work with the requirements imposed on state public infrastructure spending.

Congress Intends Greater Expansion of Municipal Use of Integrated Planning

Congressional intent to expand the implementation of Integrated Plans is manifest in additional sections of WIIA. New Section 309(h), 33 USC §1319(h), requires the Administrator to inform a municipality in any enforcement action of the opportunity to develop and Integrated Plan, and further provides that a municipality already under orders or settlement, including a judicial consent decree, may request a modification of the order or consent decree based on a developed Integrated Plan. EPA must report to Congress within two years regarding each Integrated Plan developed and implemented through a permit, order or judicial consent decree.

WIIA creates an Office of Municipal Ombudsman to provide technical assistance to municipalities to comply with the CWA, and to provide information to the Administrator to help the Administrator ensure that agency policies, including the Integrated Planning Framework, are implemented by all offices and regions of the EPA.

Lakewood already has sustained significant progress with its Integrated Planning approach under its NPDES permit without a federal consent decree. Lakewood will continue that progress under its NPDES permits as set forth in this IWWIP, as WIIA and the IPF contemplate.

Promotion of Green Infrastructure is captured in Lakewood's IWWIP

WIIA also promotes via statute the use of Green Infrastructure, defined as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems and surface waters." 33 USC §1362.

Lakewood's IWWIP is the vehicle via which it will continue its innovations in the application of green infrastructure. As explained in Chapter 2, Lakewood has already deeply integrated the use of green infrastructure in its building code, its parking code, stormwater code and other development programs. It is in the Community Vision. The pervasive public and private infrastructure work contemplated in Lakewood's collection system under the IWWIP is wholly intended to reduce flows to the sewer systems and surface waters.

4.2.2 Integrated Planning Framework

Because of its unique sewer system configurations, fully built-out land area and challenged affordability, Lakewood has integrated its wet-weather planning for over a decade. By the time that the June 5, 2012 document was issued, Lakewood was already internalizing the goals of Integrated Planning. As set forth in Chapter 2 above, Lakewood has integrated its wet-weather goals into all municipal activities. Lakewood has completed several capital projects without benefit of a consent decree.

From the time that EPA issued the Integrated Planning Framework on June 5, 2012, Lakewood has also closely followed all EPA guidance and industry discussion of the subject. The implementation includes EPA issuance and widespread use of the Integrated Planning affordability guidance, issued November 24, 2014. This IWWIP completes all six elements in the June 5, 2012 document and comports with the affordability analysis requirements set forth in the related November 24, 2014 guidance.

4.3 Control of Lakewood Overflows Requires Ongoing Iterative Process

4.3.1 Lakewood's Experience in Investigation Shapes the IWWIP

Lakewood has made continuous investments to address the wet-weather issues of its CSOs. Major investments have already increased wastewater plant capacity of from 4.5 MGD dry-weather to up to 40 MGD wet weather during some events. In 2006, Lakewood's NPDES permit required the development of a long-term control plan (LTCP). That effort utilized the tools then available and was completed in conformance with the Combined Sewer Overflow Control Policy. Unfortunately (or fortunately), that LTCP featuring a large tunnel proved grossly unaffordable upon further analysis.

In 2009, USEPA reviewed Lakewood's LTCP and its system. This coincided with a new city administration. All agreed that Lakewood's unique system required extremely close investigation to properly characterize the many sewersheds. Lakewood leveraged better, affordable investigative tools, access to more dynamic and efficient system modeling and a massive investment of manpower to investigate the entire collection system.

The investigation component has not and cannot end. Over-under sewers tributary to single-pipe sewers, and the reverse, defy simple categorization or any rote application of standard remedies. But it also means that improvements to the existing system must be made extremely carefully. For example, during this process, Lakewood has remedied several unobservable conditions which were only discoverable by investigating issues during model calibration. Based on that experience, whenever Lakewood makes changes to its system, it must engage in post-construction monitoring to evaluate how those changes have affected the rest of the system performance to avoid unintentionally increasing risk to public health or the environment, especially in the form of basement backups.

4.3.2 Risk of Basement Backups Requires Patient Remedial Efforts

Going forward, improving the Lakewood sewers will still require detailed iterative monitoring, modeling and analysis specifically to avoid creating risk of basement backups. Basement backups are the worst outcome in any wet-weather scenario. They directly impact human health through involuntary exposure. Where they occur chronically, they detract from home values and imperil the economic stability of a community. Chapter 2 records Lakewood's necessarily iterative improvement practices.

As a result, Lakewood, for example, for many years has implemented its CMOM plan. Activities under that plan include replacing missing invert plates in over-under sewers. This process, however, must be adaptively managed, because wholesale replacement is not possible without creating risk of basement backups; a missing plate in an upper reach may be added, and then the segment is monitored and modeled before one downstream can be added.

Similarly, when comprehensively reconstructing streets, Lakewood separates common manholes among the over-under sewers. This, too, requires detailed Adaptive Management. Lakewood can only proceed with manhole separation on those streets where modeling, investigation and experience demonstrate that there will be no increased risk of basement backups.

Modern monitoring and modeling make possible the risk assessment and management approach in ways that were not possible until recent decades. Lakewood's site-specific conditions preclude rushed measures that may upset the system operation without this close evaluation and monitoring of the risk. This is not a theoretical risk as some measures have required a pause until new conditions are fully understood.

4.3.3 Lakewood's Unique System Defies Easy Categorization and Remedial Alternatives Selection under the CSO Control Policy

Consent decrees to achieve Clean Water Act compliance typically use definitions that distinguish types of collection system pipes. For example, from the Northeast Ohio Regional Sewer District consent decree (*U.S. v. NEORSD*, Case No.: 1:10CV2895-DCN, emphasis added):

> "Combined Sewer System" shall mean the portion of NEORSD's collection System **designed** to convey only municipal sewage (domestic, commercial and industrial wastewaters) and stormwater to any of NEORSD's three WWTPs or to a CSO outfall.
>
> "Sanitary Sewer System" shall mean the separate portion of the Collection System **designed** to convey municipal sewage (domestic, commercial and industrial wastewater) to the WWTP.

Similarly, from Akron's consent decree (*U.S. v. City of Akron*, Case No. 5:09-CV-00272, emphasis added):

> "Combined Sewer System" or "CSS" means the portion of Akron's Sewer System **designed** to convey municipal sewage (domestic, commercial and industrial wastewaters) and stormwater through a single-pipe system to Akron's WPCS or to CSO Outfalls.
>
> "Sanitary Sewer System" or "SSS" means the portion of Akron's Sewer System **designed** to convey only sewage, and not stormwater, from residences, commercial buildings, industrial plants and institutions for treatment at Akron's WPCS.

Lakewood's collection of sewers does not fit either definition. Except for small areas near the current plant site, Lakewood's system was never designed to carry flow to any WWTP, which did not exist when sewers were designed and installed. The interceptor making the city tributary to the WWTP was added later. More broadly, Lakewood's over-under sewers were in fact consciously designed to operate as a single sewer during larger rain events. This is evidenced by the fact that across the city, relief arms from the lower "sanitary" pipe were designed and constructed to the upper pipe. Private storm sewer laterals included P-traps to keep down odors from sewage. Common construction practice of the era in which Lakewood was built included ensuring that a downspout was tied directly to the house sanitary piping. Capacity of the upper storm pipes was very limited, unable to keep larger storm events from inundating the entire system, because there was an expectation of relief through overflows.

All of Lakewood's overflows consist of "a mixture of domestic sewage, industrial and commercial wastewaters and stormwater runoff," which is the very essence of the environmental challenge of CSOs. CSO Control Policy, 59 FR 18689. The lower "sanitary" pipes were never **designed** to carry wastewater *without storm water* to treatment at a WWTP. The design of Lakewood's sewers and their eventual connection as a "system" defies categorization using only the binary options that have been imposed in enforcement practice 60 to 80 years after the sewers themselves were designed and constructed. Most importantly, the dichotomies for typical characterization do not provide a useful basis for selection and prioritization of remedial measures.

Notably, Lakewood's IWWIP does not require any changes to the permit status that has applied for more than four decades. Nonetheless, the site-specific designed features compel Lakewood's IWWIP focuses on achieving the goals of the Clean Water Act via control measures that achieve the most water quality and human health protection, and Integrated Planning intends. As the CSO Control Policy and experience have demonstrated, these measures must abide by the key principles of flexibility and a phased approach considering the community's financial capability. CSO Control Policy, 59 FR 18689.

4.3.4 Additional Policies Support IWWIP Implementation via NPDES Permit Process.

In addition to the recent Congressional action via WIIA, the federal enforcement authorities have issued recent policy documents that affirm the essential need for municipalities to maintain optimum flexibility through state enforcement recited in NPDES permitting.

Department of Justice limits use of federal consent decrees

On November 7, 2018, the Attorney General issued a directive to the Department of Justice to limit the use of any consent decrees with local governments, and limit the term of such consent decrees to a period of two or three years. Memorandum from Attorney General to Department of Justice, November 7, 2018 (available at https://www.justice.gov/opa/press-release/file/1109681/download) ("Attorney General Memo"). Though the internal memorandum creates no rights enforceable by third parties, it supersedes all contrary DOJ policies and memoranda.

The Attorney General Memo cites the interference that long-term consent decrees have on the constitutional role that local, democratically elected leadership must have. "Long-term" is defined as any period more than 24 months. The DOJ now must be highly sensitive to not reducing "long-term flexibility in how the defendant remedies the legal violation," especially where passage of time results in changed circumstances. Consent decrees that "create long-term structural or programmatic obligations, or long-term, indeterminate financial obligations for a state or local governmental entity" now require special scrutiny and approval.

The Attorney General Memo (at page 4) cites four specific circumstances when a consent decree for a local government *may* be appropriate, including any history of recalcitrance or a defendant known to be unlikely to perform. None of the four circumstances apply to Lakewood. Indeed, Lakewood's record of progress and ability to continue to deliver is well established.

The Attorney General Memo (at p. 5) affirms that consent decrees should "generally last no more than three years"; should have measurable triggers for termination; and must include a "sunset" provision and be narrowly tailored. Citing U.S. Supreme Court cases, the memorandum affirms that federal court decrees for local governments are "extraordinary remedies that raise serious federalism concerns." Federal consent decrees are not ordinary remedies.

Lakewood has been a close observer of neighboring local government entities that have detailed, multi-decade consent decrees. The programs under these very long-term decrees, like so many national examples, are highly prescriptive. Most alarmingly, those decrees have proven to be extremely difficult to modify even where circumstances have changed within the first decade of program implementation, and even when the modifications are minor, environmentally better approaches.

Lakewood's unique local conditions require a program that can respond nimbly to land use opportunities as they may arise; that can organize comprehensive street-by-street improvements leveraging state public infrastructure funding under the terms of those programs; and that can leverage investment in private property improvement that is equitable and affordable. All of those necessary features are very significantly impeded under the typical CWA federal consent decree. Managing economic change and infrastructure improvement in Lakewood cannot be sustained under such a rigid consent decree regime.

US EPA's Cooperative Federalism is realized via Lakewood's IWWIP

US EPA, citing related themes of respect for the constitutional balance for legal and efficient environmental enforcement, has in recent years strongly promoted the concept of Cooperative Federalism. See, e.g., 82 FR 46490, Draft FY 2018-2022 Environmental Protection agency Strategic Plan. Broadly, this doctrine emphasizes state primacy for enforcement under delegated programs, as well as greater communication between federal authorities and state and local governments to achieve compliance. Specific to the Clean Water Act wet-weather enforcement context, the EPA Office of Enforcement and Compliance affirmed that EPA should defer to delegated states in enforcement actions, except where certain exceptions apply. Those exception do not apply in the context of Lakewood.

Lakewood has maintained excellent communication with US EPA and Ohio EPA during its several years of capital improvement projects, system investigation and Integrated Plan development. Lakewood has completed this Integrated Planning effort as a requirement of its state NPDES permit, just as it had developed a LTCP pursuant to its NPDES permit in 2006. Lakewood's obligation to construct and operate its new High Rate Treatment facility in 2022 arises under its current NPDES permit, which must be renewed in 2019. Sustaining progress of this Lakewood IWWIP under the state-issued NPDES permit, in lieu of a federal consent decree, constitutes Cooperative Federalism in action.

Lakewood's unique local conditions must be addressed through the IWWIP via NPDES permit compliance schedules

Therefore, under the unique facts of Lakewood's circumstances—the continuously iterative nature of changing the over-under sewer system into a 21st-century system, the inherent need to react nimbly to long-term land use changes, the continuously evolving road, waterline and other infrastructure renewal, and highly sensitive affordability issues—IWWIP implementation will most effectively be continued through NPDES permit renewal. It strikes the appropriate balance between progress to implement defined, priority improvement measures and the critical flexibility of Adaptive Management.

CHAPTER 5 – SYSTEM INVESTIGATION AND HYDRAULIC MODEL UPDATE

5.1 SEWER SYSTEM AND MODEL OVERVIEW

Lakewood's sewer system consists of the sewage and stormwater runoff collection system, overflows and the wastewater treatment plant. Because of its unique configurations, Lakewood maintains a continuous, iterative process to understand and improve its system. One primary tool has been the development of a detailed, "all-pipes" hydraulic model. The intent of the model is to provide Lakewood with a tool for simulating the system's wet-weather responses, including discharge of pollutants to the environment. Water quality data from the WWTP and from the collection system were loaded and calibrated in the model. Thus, Lakewood has invested in the development of a truly integrated hydrologic, hydraulic, and pollutant model.

The model consists of approximately 345,000 LF of sanitary sewer and 365,000 LF of storm sewer of which a majority are common-trench over-under sewers, and 183,000 LF of single-pipe combined sewers intermingled across the city (Figure 5-1). During field investigations and model calibration, it became clear that interactions between the over-under sewer pipe networks exist, confirming historical design intent. The communication between the over-under sewers is modeled using orifices. Variable orifice sizes were used depending on if plates are missing, cracked, dislodged, or shut. The model was calibrated to flow data. The development of the pollutant model has become instrumental to the alternatives analysis process due to the significant interactions between the over-under sewers. The percentage of sewage present in each discharge can be quantified by the model.

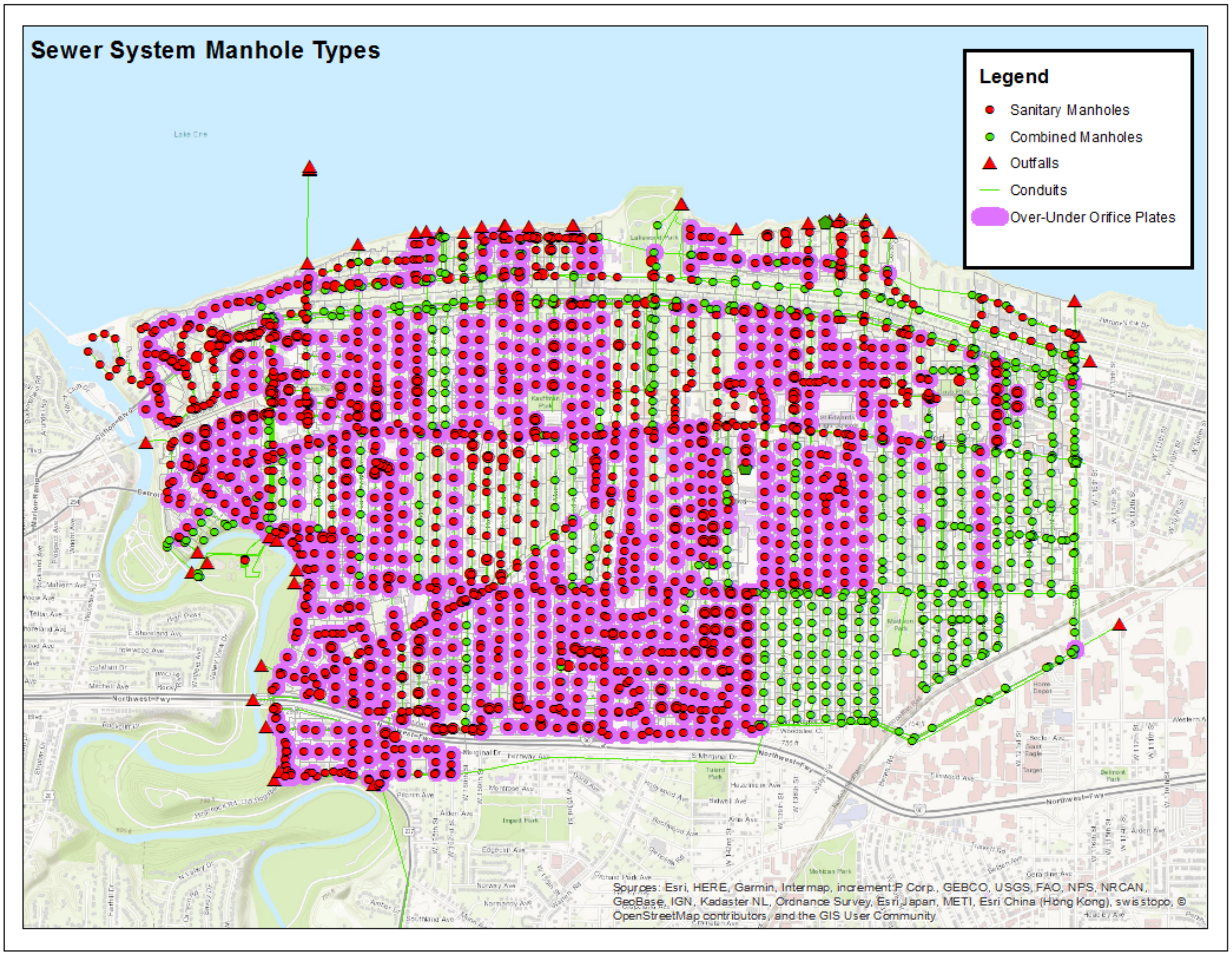


FIGURE 5-1. Modeled sewer system

5.2 STATUS OF PERMITTED CSOs

The city has nine permitted CSO locations (Table 5-1).

TABLE 5-1. City of Lakewood permitted CSOs as per NPDES permit

Station Number	Description	Receiving Stream
3PE00004052	Riverside at Madison	Rocky River
3PE00004053	WWTP West Drive entrance	Rocky River
3PE00004054	Scenic Drive - South end	Rocky River
3PE00004055	16504 Edgewater	Lake Erie
3PE00004056	15500 Edgewater	Lake Erie
3PE00004057	Lake Ave. at Lakewood Park	Lake Erie
3PE00004058	13919 Edgewater	Lake Erie
3PE00004059	12900 Lake Ave.	Lake Erie
3PE00004002 .	Overflow chamber prior to the Rocky River aerial sewer	Lake Erie

CSOs 053 and 054 have been controlled to zero overflows in a typical year as of November 2016. The West End CSO elimination project included the diversion of flows from these two overflows across the Rocky River to the wastewater treatment plant through a new aerial sewer.

CSO 002 will be controlled by the construction of the high-rate treatment facility at the WWTP. A construction contract has been awarded, and the facility is scheduled to be brought online by 2023. For more information regarding the implementation of the HRT, refer to Appendix 5-1, Actiflo and Bioactiflo Pilot Study, and Appendix 5-2, Basis of Design Memorandum High Rate Treatment Facility.

The remaining six CSOs are addressed as a part of this plan along with other combined sewage discharges through Lakewood's outfalls.

5.3 CONTINUED INVESTIGATION

Since the submittal of the IWWIP Phase 1 report, the city has invested significant time into better understanding the behavior of the sewer system through:

- Weekly field investigations
- Source control pilot study project
- CCTV efforts
- Dye testing
- Continued flow monitoring and maintenance of 60-plus meter sites
- System documentation of an 800-plus manhole photo and sketch database

- Monthly overflow reporting

Phase 2 flow monitoring, data collection, analysis, and reporting has been ongoing since the IWWIP Phase 1 report submittal. The city has installed and maintained a fleet of 67 flow meters and two rain gauges. These locations include metering of the source control pilot study area, known overflows, and ultrasonic depth-only sensors along the interceptor.

For information related to the original development of the hydrologic and hydraulic model, refer to Appendix 5-3, IWWIP Hydraulic Model Technical Memorandum.

For information related to the development of the pollutant loadings within the model, refer to Appendix 5-4, Integrated Wet Weather Improvement Plan Characterization of Pollutant Loads Technical Memorandum.

5.4 LESSONS LEARNED FROM THE ATKINS AVENUE SOURCE CONTROL PILOT PROJECT

Lakewood is in the process of completing its source control pilot project. A 102-home pilot area was selected and contractors have been tasked with removing clear water from the system.

The purpose of the Atkins Avenue source control pilot study project was to reduce the hydraulic grade line (HGL) in the sanitary sewer to prevent basement backups when performing manhole separation, and also to reduce peak flows and volumes of wet-weather to the sewer system to reduce and perhaps deactivate overflows.

Completed work within the right of way:

- Manhole separation
- Lining of sanitary main
- Top hat installations at lateral connections extended to 5 feet from the connection point in the main

Completed work on private property:

- Installation of storm and sanitary cleanouts at the ROW
- Lining of sanitary lateral from the cleanout to the foundation
- Storm lateral improvements
- Removal of all encountered P-traps

Lessons learned:

- Downspouts now were directly connected to the storm sewer, but rainwater was still finding its way into the sanitary laterals.
- P-traps in the storm laterals are plugged, preventing storm water from having a clear path to the storm sewer.

- Foundation drains were rarely present in the study area. Sanitary building drains under the basement slab act as "foundation" drains.
- The laterals were in poor condition.
- Cleanouts were generally in poor condition or nonexistent.

Recommendations for proceeding based upon pilot experiences:

- Dye test and evaluate property-by-property.
- Isolate the system if possible; engage in pre- and post-monitoring of both sanitary and storm lines.
- Replace all downspout leaders, drains, and laterals to the cleanout.
- Remove P-traps and replace with a new cleanout.
- Line the sanitary laterals from the building drain to the main.
- Separate manholes and line sanitary main.
- Install cleanouts on the sanitary lateral.

The average total private property construction value is less than $10,000 per parcel.

Construction is expected to be completed in the second quarter of 2019. Post-construction monitors are in place and will be used to continue to gather flow data. A technical memorandum will summarize the findings of the pilot study.

Model adjustments were necessary such that source control could be more accurately simulated. Primarily, it was necessary to acknowledge that a majority of the infiltration and inflow (I/I) enters the sanitary "under" system directly, not as a result of missing and cracked invert plates in the common-trench manholes. This discovery, based upon collected flow data and dye testing results, is reflected in model updates which have taken place since the submittal of the Phase 1 report.

Based upon data to be collected in post construction conditions in 2019, Lakewood plans to revisit the assumptions made when modelling source control and refine the model accordingly.

5.5 IWWIP Phase 2 Model Refinement

Tracking pollutant discharges associated with sewage is the most effective means for developing alternatives due to the significant interactions between the various sewer pipes in the system. As flow data is gathered over time, model calibrations are made. Updates made to the model improve the ability of the model to simulate overflow events, and ultimately ensure that Lakewood's capital dollars are spent as efficiently as possible.

The majority of the original calibration flow data used during model development was from meters installed in main trunk sewers throughout the city, collected primarily during a three-month summer period which was wetter than average. As long-term wet-weather flow monitoring data became available, the project team had a new source of validation data to be used in calibration.

Additionally, as with any model calibrated using a finite set of data, having long-term continuous calibration data better reflects true conditions.

There have been 628 modifications to the model since it was first completed in 2014 (Appendix 5-5, Model update log). Many changes are from new field information and discovered records which increased the accuracy of the piping network. Other changes were initiated based upon the need to calibrate to the monthly overflow reports (long-term metering sites).

The most significant of those updates are described below.

5.5.1 Climatology

The initial stormwater management model (SWMM) was calibrated to single-storm events. The starting conditions for each calibration run used no antecedent conditions. Surface storage was at zero and surface infiltration rates started at their maximum value. With the running of a typical year of rainfall, surface storage filled and never drained. Closely spaced storms produced higher runoff volumes than expected. To more accurately model long-term simulations, evaporation capability was added to the model. Although SWMM has three methods of calculating evaporation (constant value, monthly values and temperature data), the preferred method is to use daily high and low temperatures in the Hargreaves-Samani equation. Since 1977 was the basis for the typical year of rainfall, a climatology data file was prepared using daily high and low temperatures and average wind speed throughout 1977.

5.5.2 Snow Melt

With the addition of the climatology data, SWMM was able to generate snowfall and snowmelt values. In addition to temperatures, average wind speed is used by SWMM to melt snow. Although each subcatchment can have its own individual snowpack parameters, one set of values was used for all of Lakewood.

5.5.3 Infiltration

The initial model used the Horton equation to calculate infiltration of rainfall into the pervious portions of the model. Subsequent to the EPA submittal, SWMM has been enhanced to enable the modified Green-Ampt equation (which is being promoted as a more accurate method) to calculate infiltration. The GIS capabilities of PCSWMM allowed the subcatchments to be overlaid on a digital soils map to easily calculate the parameters for use of the modified Green-Ampt equations. This has been done to update the model.

5.5.4 Flow Patterns

The initial SWMM model used flow patterns to modify average daily infiltration and sewage values. Infiltration only has a monthly pattern which is used to develop the seasonal groundwater conditions. Sewage production has the capability for monthly, daily, hourly, and weekend flow patterns. With the initial model being calibrated to June-August data, values for these patterns in non-calibrated months were estimated or left for future evaluation. For the SWMM pollutant model, the tabulation of WWTP dry-weather flow values allowed for the creation of default monthly and daily flow patterns. Hourly and weekend default flow patterns were created by averaging the values from 18 of the calibration flow meters. These default flow patterns were used for non-calibrated months.

5.5.5 Mass Balance

The initial SWMM model was not in complete flow continuity balance. In general, the wet-weather water created to achieve calibration was exceeding the amount of rainfall occurring in any given simulation period. This was a function of local and generally single event calibration which aimed to achieve accurate flow results at temporary flow metering locations during a single summer. Data had been collected only during a few months during the summer of 2011. To address that situation, the city's consulting engineers, CT Consultants, recognized the need to refine the model such that it is balanced and better achieves the intent of the models development: to most accurately reflect overflow conditions during long-term continuous simulation, such as the typical year. To achieve this, the following modifications were made:

- **Created a corresponding sanitary or combined loading node for each subcatchment:** A sanitary loading node was identified for each subcatchment based upon catchment outlet nodes. This included a process where the majority of sanitary loading nodes were identified easily by changing the subcatchment outlet node name "T" to an "S". However, over 200 load nodes were selected by hand since the table conversion was not easily completed due to the fact that there was no corresponding "S" sanitary node for every "T" storm node to which each catchment loads. RTK sewershed areas were loaded to designated subcatchment specific sanitary/combined loading nodes. The area loaded included a summation of all building footprint areas within the model subcatchments based upon the most recent county GIS dataset for building footprints.

- **Selected 100 percent R Value methodology:** Since original RTK unit hydrographs were developed and calibrated using R values which reflect flow from the entire catchment (not just the building footprints), the pre-existing RTK Unit Hydrographs were no longer valid loadings. In an attempt to mass balance the model, a blanket RTK unit hydrograph approach was taken which requires a total R value equal to 100 percent. This assures us that the model can be balanced since total water contributed by the rooftops is fully accounted for. Blanket RTK unit hydrographs were created in the model and loaded at every sanitary RTK sewershed loading node. These hydrographs included total R values equaling 100 percent with a breakdown of R1 = 70 percent, R2 = 20 percent, R3 = 10 percent. Other sets were developed to assist with model refinement such as 50, 30, 20, and 85, 10, 5. This methodology is backed by the Atkins Avenue pilot study efforts which revealed that the flow from the rooftop generally made its way into the sanitary system. It was recognized that not all of the rooftops are directly connected, which is why a portion of the area is loaded under R2 and R3 values.

- **Reduction of Total Subcatchment Area:** Due to the loading of all building footprints via RTK sewershed areas, the area of those footprints was removed from the base subcatchment to avoid double counting of runoff from those footprint areas. The model subcatchment area of each physical/real subcatchment was reduced by the sum of building footprint area in that particular subcatchment.

- **Update to Percent Impervious for Each Subcatchment:** Shifting of the impervious area represented by the building footprints to the RTK sewershed area loading required that a compensation be made to assure that the total impervious area prior to the adjustment is preserved.

  Original total impervious area = Building Footprints + Remaining Impervious Area of the Subcatchment

  The remaining impervious area of the subcatchment was used to update the percent impervious against the remaining total area of the subcatchment.

- **Rain Gauge Refinement:** Multiple rain gauges were used to develop rain gauge files. The rain gauges are located at the fire station and city hall; the previous model included only city hall rain gauge data. This is intended to improve the spatial accuracy of the rainfall used to run the 2017-2018 model for comparison against overflow data on a site by site basis.

- **Overflow by Overflow Model Refinement:** Having brought the model into mass balance, attempts were then made to refine the ability of the model to accurately predict overflows specifically at each overflow shed. To achieve this, updates were made on an overflow shed by overflow shed basis to adjust subarea routing, percent routed, conductivity, and ultimately RTK sewershed areas. If any sewershed areas were manipulated, a corresponding change was made to the subcatchment values to keep the model in balance. Making a sewershed area change suggested that the catchment was acting such that less than 100 percent of the building footprint area was routing directly to the sewer (and was therefore routing as runoff).

5.5.6 POLLUTANTS

To analyze potential alternatives, a question arose as to how much of the volume discharged at each outfall originated as sewage. Related questions included how much of the discharge originates as RDII, Lakewood infiltration and runoff, and Cleveland infiltration and runoff. To investigate these questions six "dummy" pollutants were created and coefficients set such that one MG of volume from any of the six sources was represented as pound of the respective dummy pollutant. This configuration allows the modelers to calculate CBOD discharged at each outfall, which is contributed by sewage.

5.5.7 REGULATOR DIMENSIONS

In the initial model, regulator dimensions were based on general observation due to confined space requirements. In 2015 and 2016, flow meters were installed in 95 percent of the regulator manholes. The installation procedure included a confined space entry and collection of detailed measurements within the manholes (weirs, vertical offsets, and pipe sizes). Differences between field measurements and the previous observations were small, but the model was updated to reflect these more accurate measurements. In addition to taking measurements, the meter installation crew looked up and down the pipes. There were several locations where the crew observed a pipe size reduction downstream of the manhole. The SWMM model was changed to reflect these smaller pipes.

5.5.8 Rainfall Dependent I/I Changes

With the initial model being calibrated to June-August data, values for RDII in non-calibrated months were estimated or left for future evaluation. For the initial SWMM model, the average RDII values from the three calibration months were applied to the non-calibration months. Based on comparisons of metered overflows to actual overflows, it was apparent that too much RDII was being generated by SWMM. For the over-under sewer areas, further research showed that the acreages associated with RDII were the whole subcatchment areas instead of the areas tributary to the lower sanitary sewer. For the updates to the SWMM model, the acreages for RDII values was reduced to roof acreage to account for the various sources of RDII on private property.

Secondly, based upon observations made from Atkins Avenue pilot study, and based upon the ability of the model to simulate overflows accurately, it was determined that approximately 80 percent of the rooftop areas contribute directly to the under sewer, with only 20 percent contributing directly to the storm sewer. This is primarily due to plugged P-traps and dilapidated private systems. Over time, the private property systems have deteriorated and water has created small lenses or pathways to quickly enter the sanitary lateral from the rooftops, near the perimeter of the home and between the storm and sanitary laterals.

5.5.9 WWTP

To separate the mass of pollutants discharged to Rocky River as compared to Lake Erie, the WWTP unit processes and the outfall sewer were added to the SWMM model. The outfall sewer begins at the outfall head chamber on the east side of Rocky River. The outfall sewer runs north 5,400 feet to the shoreline of Lake Erie then extends 1,800 feet under the lakebed and ends with three sets of diffusers. The portion under the lake bed was given an initial depth equal to the lake level.

5.5.10 CSO 002

CSO 002 is located at the WWTP influent head chamber. Its overflow pipe was redirected to the outfall sewer head chamber. The SWMM model was under-predicting overflows at CSO 002 for several possible reasons. One possible reason was that the outlet piping from the influent head chamber to the outfall head chamber was too steep. This was corrected with a more detailed physical configuration in the model. Another possible reason was that the interceptor sewer was not delivering flow fast enough to cause an overflow. This was corrected by reducing the Manning's "n" factor from 0.015 to 0.013 (a more common factor for large conduits). A third factor was the location of the flow limiter in the model. Based on stress testing, it was determined that the maximum hydraulic capacity of the WWTP is 40 MGD. WWTP operators limit flow through the plant to 40 MGD by partially closing gates in the influent head chamber. To model this limiting factor, the initial model placed a limiter on the WWTP influent pipe downstream of the mixing chamber. With this location, SWMM allowed too much flow to come in from the head chamber which caused flooding at the mixing chamber. This was corrected by placing a pseudo pipe in the head chamber with a limit of 35 MGD to the mixing chamber (this allows 5 MGD to come in through the new aerial sewer). The 40 MGD limiter downstream of the mixing chamber is still in place.

5.5.11 West End Aerial Sewer

Prior to construction of the West End aerial sewer, sewage from Rocky River and Metroparks was pumped to the sewer that flowed past CSO 053. With the construction of the aerial sewer, this pump station was added to the model with a discharge pipe to the WWTP influent mixing chamber.

5.5.12 Lake Avenue Storm Sewer

Activation of CSO 058 (LEWS 1110) was largely influenced by a large storm sewer (draining an area south of Lake Avenue) that was connected to the combined sewer. A new storm sewer was constructed to redirect this storm sewer to an existing stormwater outfall at LEWS 1130. The model has been updated to reflect the completion of this project.

5.5.13 CSO 052 Sensor relocation

The 052 sensor (RRES 1160-1165) has been scheduled by the city for relocation. Previous year monitoring results report the absence of overflows at this location, which the city believes to be inaccurate. Additionally, the model predicts overflows at this location. The meter will be moved to a downstream manhole and placed in a pipe location expected to better provide metering results which will allow the city to better validate the sewer model. The results from the improved monitoring location will be available beginning in March of 2019. These results will be used to validate and verify alternatives for the CSO 052 sewershed as soon as possible.

5.5.14 Integrated NEORSD Interceptor Model

The model was expanded in 2017-2018 to include integration of the NEORSD Northwest Interceptor Model and Westerly Interceptor Model. This advancement in the model allows an evaluation of the impact each sewer system has on each other and creates the ability to better understand the alternatives available to the city for regulation of CSO 059. Ultimately, to limit the extent of an already complex and large model, timeseries are loaded to the Lakewood model at four load points to represent the presence of NEORSD system flows. These timeseries were developed for 1977 and 2017-2018 time periods using the NEORSD Northwest and Westerly Interceptor Hydroworks model.

5.5.15 Other Interceptor Adjustments to the Model

The slope and shape of the interceptor were refined based upon as-built drawings to better reflect the egg-shape cross-section of the sewer, and the 0.001 slope at which the interceptor was constructed. These improvements proved critical in the validation of CSO 002 and CSO 059.

5.6 Design storm justification

Understanding that the model has been developed to simulate overflows and serve as a tool by which the city can evaluate alternatives, CT has completed an analysis to determine the appropriate duration of design storm to be used when performing design storm analysis. Please refer to Appendix 5-6, Design Storm Derivation.

5.7 Model Validation

During field investigations over the past several years, upwards of 60 overflow locations were found and are believed to discharge through Lakewood's outfall pipes either to Lake Erie or the Rocky River.

Valuable flow data has been collected at these locations since the submittal of the IWWIP Phase 1 report. In conjunction with continued investigation and knowledge gained, many enhancements were made to the model as described previously in this report. This prompted the model team to perform a validation exercise with the model prior to completing the alternatives analysis. The details of the validation can be found in Appendix 5-7, Validation Model Results, and a summary Table 5.2 is provided below. The table uses WaPUG Criteria to provide an overall review of the models accuracy. The city has focused its efforts on the larger volume monitoring sites, reporting 91 percent of the overflow volumes are "fairly well calibrated" or "well calibrated." The sites which are not well calibrated represent a small portion of the area and minimal volume of overflow generated in the city. Additional focus will be given to these sites as the model is further refined in the future. These results are another example of Lakewood's commitment to the continuous refinement and betterment of the model, and are a work in progress.

TABLE 5-2. Model validation summary

Rating	Number of Sites	% of Total CSO Vol.	Accuracy
Good (Meets WaPUG)	24	60%	-20% to +30%
Fair	12	31%	-50% to +50%
Poor	22	4%	Worse than -50% to +50%
n/a	4	5%	No reliable meter data
Totals	62	100%	

5.8 Existing Conditions System Performance – Typical Year Results

The alternatives presented later in this report are based upon the model's ability to track pollutants associated with sewage back to their source, and make improvements to prevent discharge associated with sewage from leaving the system untreated. Table 5.3 below offers a better understanding of where the system currently discharges pollutants associated with combined sewage. Due to the complexity of the system, many of the sewer systems contributory to the outfall discharges are affected by one another, either through cross connections between sheds or interaction with the interceptor. Figure 5.1 visually relates the sewersheds to the typical-year-results table.

TABLE 5-3. Existing conditions model outfalls – typical year discharge results

Source Information					Existing Conditions		
MODEL .INP Name:	Master Model 2018-12-03.inp						
Site Specific Results							
Outfalls	**CSOs (Permit # if applicable)**	**Reporting Link**	**Volume (MG)**	**TSS Total (lb)**	**CBOD Total (lb)**	**CBOD by Sewage (lb)**	**E. coli TCU**
059ALEWS1040		059AC001_059BLEWS1040	101.98	13619	7539	5072	5.83936E+15
052RRES1160	052 Outfall	052T003_052RRES1160	159.52	20892	10408	4195	5.45011E+15
002LEWS1195		002T4648_002LEWS1195	14.52	2342	1346	1027	1.15433E+15
002LEWS1070		002T1301_002LEWS1070	13.79	1915	1114	908	1.01038E+15
002RRES1145		002T4413_002RRES1145	40.66	2744	1367	687	8.46092E+14
056LEWS1180		056C283_056LEWS1180	11.31	1953	1075	681	7.9282E+14
056LEWS1150	056B Outfall	056C490B_056LEWS1140	23.16	1705	866	414	5.13683E+14
057LEWS1135	057 Outfall	057C343_057LEWS1135	4.20	587	337	258	2.89908E+14
059LEWS1035	059 Outfall	059C1020_059LEWS1035	22.86	657	308	155	1.938E+14
059LEWS1045		059BS012_059LEWS1045	2.17	341	199	152	1.71257E+14
059LEWS1055_1060		059BT1003_059LEWS1055_1060	16.35	648	309	113	1.51434E+14
002LEWS1295		002T231_002LEWS1295	10.32	447	179	60	8.40241E+13
055LEWS1225	055 Outfall	055C001_055LEWS1225	2.45	157	71	10	2.01681E+13
057LEWS1130		057T344A_057LEWS1130	29.81	417	139	7	3.14687E+13
052RRES1180		052T041_052RRES1180	1.10	48	22	3	5.8159E+12
002LEWS1190		LEWS1190-PSEUDO_LEWS1190	0.06	9	5	3	3.30919E+12
002SRRES1065		002T096_002SRRES1065	5.17	275	110	1	1.7634E+13
002LEWS1220		002C238_002LEWS1220	0.01	1	0	0	1.93715E+11
052RRES1215		052T157_052RRES1215	4.60	82	31	0	5.04061E+12
052RRES1165B		052T001_052RRES1165B	0.04	1	1	0	1.15549E+11
002LEWS1210		002T242_002LEWS1210	0.23	4	2	0	2.60409E+11
056LEWS1155	056A Outfall	056C915A_056LEWS1155	1.67	102	49	16	2.23688E+13
058LEWS1110	058 Outfall	058C001B_058LEWS1110	0.00	0	0	0	0
002LEWS1215		002C3906_002LEWS1215	0.84	19	4	0	8.26406E+11
002LEWS1230		002T235_002LEWS1230	0.07	1	0	0	47260300839
002LEWS1285		002C232A_002LEWS1285	0.00	0	0	0	0
002RRES1150		052T2002_002RRES1150	0.00	0	0	0	0
052RRES1185		052T142_052RRES1185	13.36	1358	579	0	8.94592E+13
052RRES1220		052T1479_052T01	0.58	7	2	0	3.83135E+11
053RRWS1200	053 Outfall	053S001_053RRWS1200	0.00	0	0	0	0
053WWTP		053C002_053WWTP	0.00	0	0	0	0
054RRES1140	054 Outfall	053C1001_054RRES1140	8.76	210	84	0	1.29464E+13
059LEWS1050		059BT003_059LEWS1050	1.58	41	11	0	1.93746E+12
059LEWS1005		059C1012_059LEWS1005	7.38	143	39	0	6.3823E+12
	WWTP OUTFALL (002)	CSO-002	36.66	6493	3610	2413	2.78037E+15

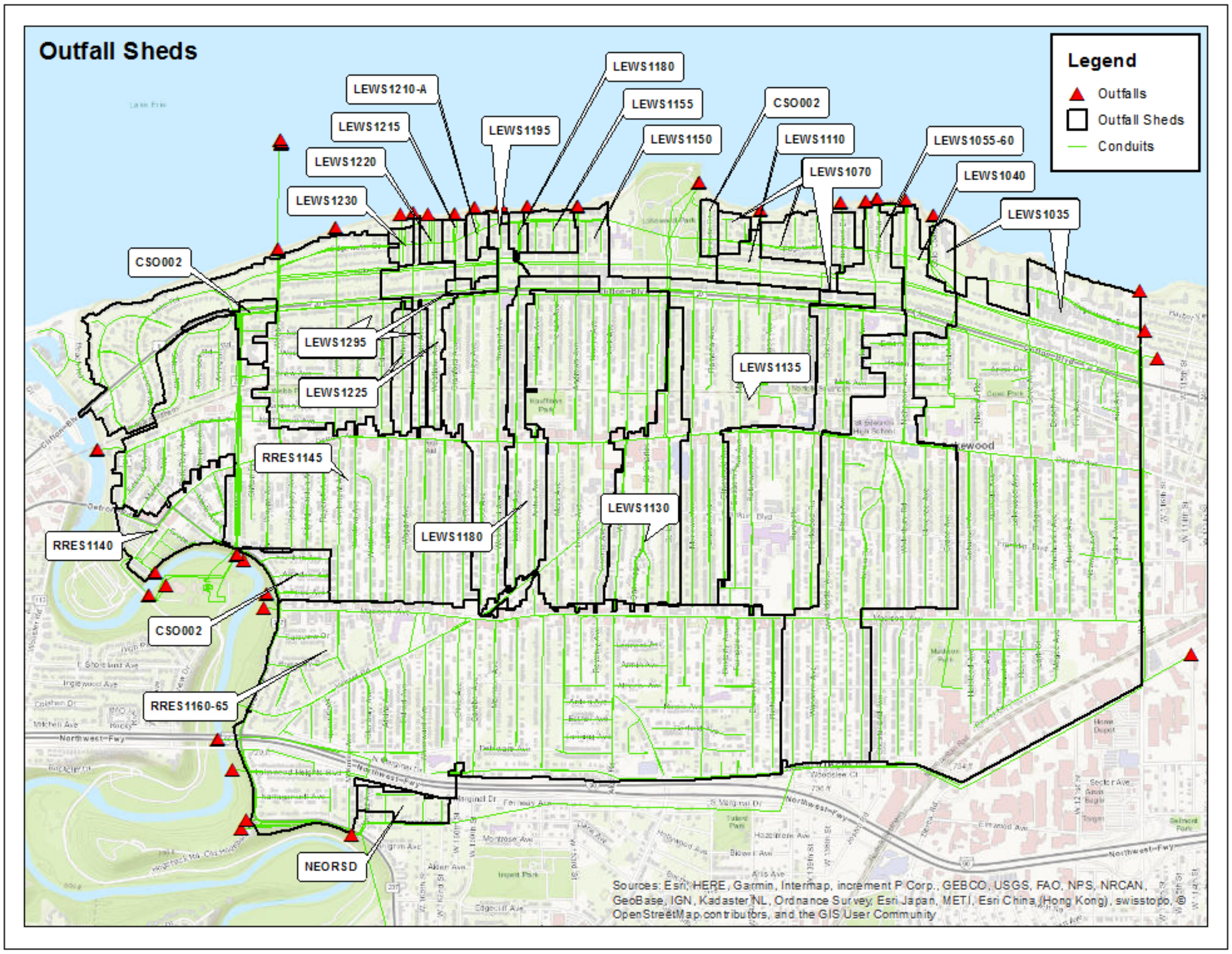


FIGURE 5-2. Outfall sheds

In summary, Lakewood's hydraulic model was first reported on in the attached IWWIP Hydraulic Model Technical Memorandum, and further calibrated for the Phase 1 IWWIP report in 2016. Since then additional flow monitors, pilot studies, NEORSD influences, and overall refinements have led to the development of a useful tool that has been validated with 2018 data. In 2019, results from the pilot study area and overflow sites will allow the city to perform additional validation using the data to compare against existing conditions and also refine assumptions made with regard to source control modeling in the alternatives analysis phase.

CHAPTER 6 – ALTERNATIVES EVALUATION APPROACH

Lakewood's Integrated Wet Weather Improvement Plan Phase 2 effort is required by the city's NPDES permit to include an alternatives analysis that considers cost-effectiveness, in terms measured by the frequency of discharges, discharge volumes, and discharged pollutant loadings. This chapter outlines the approach by which this permit requirement has been satisfied to the extent applicable to the city's discharges.

6.1 ALTERNATIVES ANALYSIS FRAMEWORK

Consistent with the NPDES permit requirements, the "alternative analysis" approach supporting this IWWIP considers the cost-effectiveness of potential alternative improvements. Previous chapters have explained the unique nature of the Lakewood sewer system based on its intermingled sewer types. Due to this central fact, the alternatives analysis framework must be tailored to address the unusual conditions.

The framework accounts for a determination of cost-effectiveness, in which the incremental system improvements gain is compared to the cost estimated to achieve those gains. Figure 6-1 illustrates the basic mapping of outfall, level of control, and technologies that was the basis for this alternatives analysis framework. In this framework illustration, control at Outfall X considers three different technologies (for example, "Storage" or "Relief Sewer"), but not all are viable at each of the three levels of control (for example, "4 per typical year") shown. Further details on levels of control and technologies are provided in sections 6.2 and 6.4, respectively. As pollution control for each city outfall was considered, only those technologies viewed as viable were developed for further analysis.

	Level of Control 1	Level of Control 2	Level of Control 3
Outfall X	Technology A	Technology A	Technology C
		Technology B	

FIGURE 6-1. Alternatives analysis framework

6.2 LEVELS OF CONTROL CONSIDERED

The term "level of control" is intended to mean the frequency or conditions in which an untreated discharge of wastewater would occur from an outfall with the identified controls (projects) in place. When considering CSO discharges, level of control is described in the context of a typical year and how many times untreated discharges would occur if a year such as that were to occur with the controls in place. In addition to activations, level of control also means for the stated control objective that basements would not be adversely affected. This was especially true in areas with no regulator, which drain directly to the interceptor. For example, from this viewpoint, the two-year control objective would also prevent basement back-ups from occurring in the two-year or lesser event. For other parts of the system, specific design storm events are used and the designated performance indicates whether the controls prevented discharge in that event. Chapter 5 provides an in-depth description of the sewer model that was used for system performance analysis under both typical year and specified design storm conditions.

Specific levels of control considered in this plan include the following:

- Four untreated discharges per typical year
- Three untreated discharges per typical year
- Two untreated discharges per typical year
- One untreated discharges per typical year
- Zero untreated discharges per typical year
- Zero untreated discharges in the two-year, two-hour storm
- Zero untreated discharges in the five-year, two-hour storm
- Zero untreated discharges in the 10-year, two-hour storm

Based upon comments received from the US EPA and DOJ (August 2018), an analysis was completed to select an appropriate design storm duration for use in evaluating alternatives. The result of this analysis was justification for selecting two-hour design storm event durations.

For the alternatives analysis of technologies at individual outfalls, full typical year simulations were not performed, due to the time required for such an extensive analysis. Instead, the largest five storm events from a rainfall-intensity perspective were selected from the typical year record and limited simulations of these events were performed for sizing alternatives. As discussed below, full-year continuous model simulations were run for the various systemwide solution sets.

As noted in Chapter 5, significant portions of the Lakewood storm sewer system, including the portions that are combined, begin to excessively surcharge in events exceeding the two-year, two-hour storm event. For this reason, levels of control beyond 10-year event were not considered, as achieving this would require massive, infeasible investments in upgrading the storm sewer system conveyance capacity in the city.

6.3 Model Output Review

As noted in Section 6.2, a sewer model was used to evaluate the impact that any considered alternative would have on reducing the occurrence of untreated wastewater discharges in wet-weather events, whether during typical year events or specified design storm events. In Lakewood's case these untreated discharges could occur at CSO regulators, where combined sewage can overflow a weir and discharge to a storm sewer, or at an open or compromised invert plate in an over-under common-trench system.

The sewer model description in Chapter 5 explains that the Lakewood model includes sanitary, storm, and combined sewers. The model simulates rainfall-runoff processes and pollution generation and transport processes. This calibrated, complex model is capable of simulating the transport and discharge of pollutants associated with wastewater and storm water. Altogether, the model represents the 36 outfalls that can discharge from the Lakewood system to the environment, including the Lake Erie outfall tunnel serving both the WWTP and CSO 002. As such, model outputs include, but are not limited to, the total volume, total suspended solids (TSS), CBOD, Sewage CBOD, and *E. coli* loadings discharged at each outfall during each simulation. When controls are included in the model, the difference in discharged volume and pollutants can be calculated and compared to existing conditions at each outfall.

6.4 Technologies Considered

As required by the NPDES permit (3.b.i. 1 through 7), the following alternative technologies were considered for reducing the CSO volume, frequency, and pollutant loading attributed to the sewer system in specified meteorological conditions. Not all technologies are applicable to all discharges. Below is the list of technologies listed by the permit and considered within the IWWIP Phase 2:

- Sewer separation, both in targeted local areas as well as system-wide
- Storage basins or tunnels
- Express sewers to convey sewage for treatment at the wastewater treatment plant (WWTP) or a satellite treatment system
- Use of satellite treatment systems in the collection system, including physical-chemical treatment
- A combination of the above alternatives

The following is a discussion of each applicable technology, how it was considered in this alternatives analysis, and what limitations influenced the levels of control in which it was utilized.

6.4.1 Sewer Separation Technologies

Sewer separation is performed to reduce the hydraulic load on the sewer system tributary to the WWTP and reduce the frequency, volume, and pollutant loading associated with untreated sewage charges. Three types of sewer separation technology were considered as alternatives, depending upon which type of system existed in an area and the level of control desired. For streets served by over-under sewers, two levels of sewer separation were considered. For lower levels of control (generally up to zero per typical year sewage discharge events), public system separation was considered and included separation of manholes, rehabilitation of sanitary sewer mains, public portions of the sanitary sewer lateral, and removing the P-trap on the storm lateral and installing a test tee on that pipe at the property line. For higher levels of control on over-under systems (two-year event to 10-year event control), full system separation including private source control was considered. For areas served by combined sewers, green infrastructure installation and full system separation in the right of way were evaluated to achieve levels of control up to zero per typical year. For further discussion of how modeling supported analyses of these different separation technologies in specific portions of the system, please refer to Chapter 7 of this IWWIP Phase 2 report.

6.4.2 STORAGE TECHNOLOGIES

Storage is used to hold peak flows that are in excess of the capacity of conveyance and treatment facilities until such time that capacity is available to drain the stored volume. Storage can be accomplished with either pipelines or tunnels, or below- or above-ground storage tanks. Industry-recognized important considerations for sizing storage are the peak flow event or events used to determine at what point storage needs to be engaged; how much volume will need to be captured; and the rate at which storage volume can be recovered in time for the next storage event.

The IWWIP Phase 2 plan considered storage tunnels/pipes, below and above ground storage. Storage analysis with the modeling occurred in two phases. Preliminary analysis involved sizing storage to capture specific significant peak flow events in the typical year or specified design storms of a certain frequency, for each outfall. For typical year performance, the following model setups were used:

- **Four per typical year**: Storage required to prevent discharge in *fifth-largest* peak flow event.
- **Three per typical year**: Storage required to prevent discharge in *fourth-largest* peak flow event.
- **Two per typical year**: Storage required to prevent discharge in *third-largest* peak flow event.
- **One per typical year**: Storage required to prevent discharge in *second-largest* peak flow event.
- **Zero per typical year**: Storage required to prevent discharge in *largest* peak flow event.

Later, when combinations of projects across all discharge sites were assembled into a single model, an entire typical year rainfall series was simulated to determine storage requirements at specified locations to prevent discharges at these same frequencies.

Storage requirements for design events were determined by modeling individual events, according to the assigned frequency and duration for the analysis.

Chapter 7 provides details for how storage was used as an alternative for controlling sewage discharges at specific sites and levels of control.

6.4.3 EXPRESS SEWER TECHNOLOGIES

Express sewer technology is a consideration for conveying flows from a defined area to a downstream point where another control technology, such as storage or treatment, is available to manage untreated discharges at the desired level of control. The term "express sewer" is used because flows from the served area are exclusively conveyed in this sewer and there is no opportunity for other discharges into this sewer from areas through which the sewer is routed. For reasons explained in Section 6.4.4, Treatment Technologies, express sewers to the WWTP were not considered for IWWIP Phase 2; however, express sewers were considered to convey flows from certain areas to centralized storage controls. Chapter 7 provides further details on which alternatives utilized express sewers to manage pollutant discharges at some sites.

6.4.4 TREATMENT TECHNOLOGIES

Treatment technologies cover a broad range of approaches for reducing pollutant discharges, including bacteria, from the sewer system during wet-weather events. Included in this technology group are screening, traditional primary treatment, traditional secondary treatment, physical-chemical high-rate primary treatment, high-rate biological treatment, and disinfection. One important consideration for the Lakewood IWWIP Phase 2 is whether these technologies are appropriate for Lakewood's system and the desired reduction in sewage pollution discharges. For this plan, only satellite treatment of discharges was considered and for only one outfall, but a wide range of technologies were evaluated for that site. Chapter 7 provides further details on the specific treatment technologies considered at this site.

The permit references evaluating the extent to which additional treatment capacity can be added at the existing WWTP facility. In Lakewood's case, however, additional treatment at the WWTP, and the additional conveyance capacity to the WWTP to take advantage of this treatment capacity, were evaluated as infeasible alternatives. The current WWTP and the HRT, under construction at this time, together have capacity that matches the Lake Erie outfall capacity. Under peak wet-weather flow conditions, both the WWTP and the HRT will be operating at maximum capacity and will completely utilize the outfall pipe. Any additional HRT or WWTP capacity would also require either a new outfall pipe to Lake Erie or the Rocky River. Furthermore, the influent interceptor (along West Clifton Boulevard) capacity to the WWTP (upstream of the river crossing) roughly matches the combined treatment capacities of the two facilities, so any treatment capacity would need to be coupled with both outfall capacity and influent conveyance capacity. In consideration of these realities, the city determined scenarios involving more WWTP capacity to be infeasible.

6.5 BASES OF COMPARISON

Typically, in a wet-weather control plan, the bases of comparison for different alternatives and different levels of control would be volume of discharge reduced, frequency of discharge reduced, and different loadings of pollutants reduced. For a given level of control at a specific site, it is desirable to know what alternative technology is most cost-effective. Likewise, it is desirable to know the cost-effectiveness of incrementally higher levels of control, typically expressed in terms such as dollars per gallon controlled or dollars per pound of pollutant controlled.

Due to the types of alternatives considered for this IWWIP and the nature of Lakewood's system, some bases of comparison, such as volume of overflow reduced, are difficult or impossible to evaluate in terms of cost-effectiveness. For instance, the over-under sewer systems were designed to provide many recognized paths for the sanitary sewer flows to discharge into the storm sewer system above, and for the storm system above to drain into the sanitary sewer system below. In such a system, volume control is not straightforward to calculate, as these discharges occur at many locations such as invert plates located at manholes. Likewise, some solutions for this situation that cause less sewage contamination to the flow discharging through the outfall may cause no meaningful reduction in volume, and even may cause an increase in volume if stormwater runoff is taken out of the sanitary sewer. From this perspective pollution reduction, and in particular sewage-originating pollution reduction, Sewage CBOD is the best basis for comparing alternative technologies and levels of control.

In a more traditional combined sewer system, the volume of overflow controlled would be the reduction in discharge volume from the combined sewer overflow. Given the integrated nature of this IWWIP, however, it is further recommended that combined sewer discharge controls be sized to achieve the previously mentioned levels of control but be evaluated on the basis of Sewage CBOD controlled.

Despite the demonstrated utility of focusing on Sewage CBOD control, all developed alternatives were evaluated on the basis of volume reduced, pollution reduced, and bacteria reduced at each outfall. Sewage CBOD was chosen as the primary gauge for developing individual alternatives and assessing the performance of the system. Review of modeling results indicate that the modeled discharge of *E. coli* (regardless of source) matched very closely to Sewage CBOD in terms of concentration rank. In other words, the outfalls with the highest modeled *E. coli* concentration also had the highest concentration of modeled Sewage CBOD. In general, the model's estimation of Sewage CBOD generation and discharge is believed to be much more reliable than *E. coli* because the model's representation of CBOD generation can be compared to what is measured at the influent to the WWTP. A comparison of 2017 and 2018 influent conditions determined an average daily loading of CBOD of 5,060 pounds. The typical year model influent CBOD is approximately 5,000 pounds per day. No similar comparison is available for *E. coli* as the city does not sample for this parameter in its influent.

6.5.1 Existing System Sewage Pollution Control Performance

To provide a proper perspective of the additional sewage pollution improvements that any alternative levels of control may achieve, it is important to first establish what the existing system achieves. To estimate this, the city's engineering consultant, Brown and Caldwell, reviewed the eDMRs for the Lakewood WWTP in 2017 and 2018 to determine the amount of pollution reduction achieved by the WWTP. Over this two-year period, the average CBOD influent concentration was 90.8 mg/L and the effluent concentration was 2.4 mg/L.

Using the recommended approach in the May 2012 CSO Post Construction Compliance Monitoring Guidance from US EPA (page 44), the following was determined with this review:

- Lakewood's WWTP currently removes 97.4 percent of CBOD received on average.

- When considering typical year Sewage CBOD mass discharges through outfalls, the system wet-weather event capture (including the WWTP discharge) is 93.7 percent.
- After the HRT, currently under construction, begins operating, the wet-weather system capture will increase to 94.1 percent of CBOD.
- Due to performance limitations of the WWTP and the HRT, the maximum wet-weather system capture that ever can be accomplished with elimination of untreated sewage discharges is 97.5 percent in a typical year.
- Under all of these conditions, Lakewood already meets the 85 percent capture criterion for CBOD pollutants during precipitation events according to CSO Policy.

A technical memo dated February 28, 2019 fully documents these findings and is included as Appendix 6-1.

6.6 TRANSITION FROM OUTFALL-SPECIFIC SOLUTIONS TO SYSTEMWIDE SOLUTION SETS

The alternatives analysis process followed for the IWWIP Phase 2 plan involved a two-step process. First, outfall-specific alternatives were developed and evaluated to identify the most cost-effective approach for achieving the desired level of control for each outfall. After this step was completed, full systemwide sets of solutions were assembled to achieve a systemwide level of control outcome.

In the course of moving from the outfall-specific perspective to the systemwide perspective, the sizing and cost of some outfall-specific solutions changed slightly. Initially, the sizing of alternatives was based on the largest typical year storms that would drive sizing of improvements. Ultimately, the final solutions were based on full typical year simulations of the entire sewer system. As a result, some cost figures for solutions defined in the outfall-specific solutions discussion may not match the cost figure included for that solution in the systemwide solution set it belongs to.

Lakewood's IWWIP anticipates that as new improvements come on line, this modeling and analysis will be adaptively managed so that the next improvement fully accounts for changes to the unusual system and the next best alternative is selected. This will ensure a system of ongoing improvement and updating that is consistent with the 2012 Integrated Planning Framework, Element 6.

CHAPTER 7 – EVALUATION OF ALTERNATIVES

Lakewood's Integrated Wet Weather Improvement Plan (IWWIP) Phase 2 report is based on a robust alternatives analysis that considers a wide range of technologies, levels of control, and cost-effectiveness of solutions. This chapter details the development and analysis of alternatives using the process defined in Chapter 6.

The alternatives screening and analysis for this report was conducted in two steps:

- Step 1 was a site-by-site analysis looking at cost-effective solutions which may be feasible for each outfall. Step 1 is summarized in Chapter 7.
- Step 2 included tracing of pollutants and refining the site-by-site alternatives developed in Step 1 while developing composite (citywide) solution sets and costs. Step 2 is summarized in Chapter 8.

For each Lakewood outfall, the alternative solutions considered for each level of control are described. Water quality and volume results are included in Appendix 7-1 – Site-by-Site Matrix Discharge Results. These results generally report total wet-weather flow from the modeled discharge points. Results reflect each outfall as being evaluated independently. Many of the alternatives eliminate sewage discharge through the respective outfalls, but still discharge stormwater through the outfall. Therefore, as noted in the appendix, many of the results are reported as stormwater only totals for Step 1. Further investigation and modeling completed as a part of Step 2 identified CBOD contributed by sewage at each outfall, and results are presented in Chapter 8 on a systemwide basis.

7.1 SITE-BY-SITE ANALYSIS OVERVIEW

Site-by-site analysis was completed by analyzing all outfalls that were predicted to have CBOD coming from sewage during the typical year. The goal was to come up with local solutions that resolve all sewage discharges. Due to the interconnected nature of the system, some overlap occurs with neighboring sewersheds within Lakewood. Therefore, it was anticipated that some of the results and costs overlap. These overlaps were reconciled when creating composite (systemwide) solutions in Step 2.

The outfalls may still discharge volume and CBOD related to stormwater after the improvements are completed. For example, an upstream CSO controlled to zero per typical year (0/TY) does not completely eliminate flow from an outfall sewer if there are other storm sewers connected to the system upstream of the outfall. Therefore, volume and CBOD discharged are not expected to be zero in all cases, but generally show trends of improvement as increasing levels of control are achieved.

Due to the large number of model runs, model run time constraints, and the ability to glean effectiveness from a shortened typical year run period, a five-event time period including the five highest peak rainfall events of the typical year was simulated to evaluate all CSO control alternatives for site-by-site analysis. These five-event results were taken as a snapshot in time to make decisions and move forward with composite scenarios. For the non-CSO control objectives, a total of three models were simulated: two-year, five-year, and 10-year design storms, each with a two-hour duration. The justification for selecting a two-hour duration can be found in Appendix 5-6 – Design Storm Derivation. Continuous typical year modeling was performed for the composite solution sets as described further in Chapters 5 and 8.

7.2 RRES 1160-1165

CSO 052, or RRES 1160-1165, discharges to the eastern shore of the Rocky River, across the river from the WWTP. The sewered area tributary to CSO 052 comprises single-pipe combined sewers and over-under sewers. At each manhole in the sewer service area, an opening exists in the bottom of the upper sewer that may be missing or ineffective at preventing the comingling of flow from the two pipes. As a result, the entire 520-acre tributary area is effectively a combined sewer system. Hydrologic, hydraulic, and water quality modeling has determined that the discharge to the Rocky River at outfall RRES 1160 contributes the most organic loading to surface waters (in terms of total CBOD) and nearly the most Sewage CBOD and *E. coli* when compared to all other similar discharges. As such, this location is either the highest or second-highest water quality priority for the city. Figure 7-1 shows the CSO 052 (RRES 1160) service area.

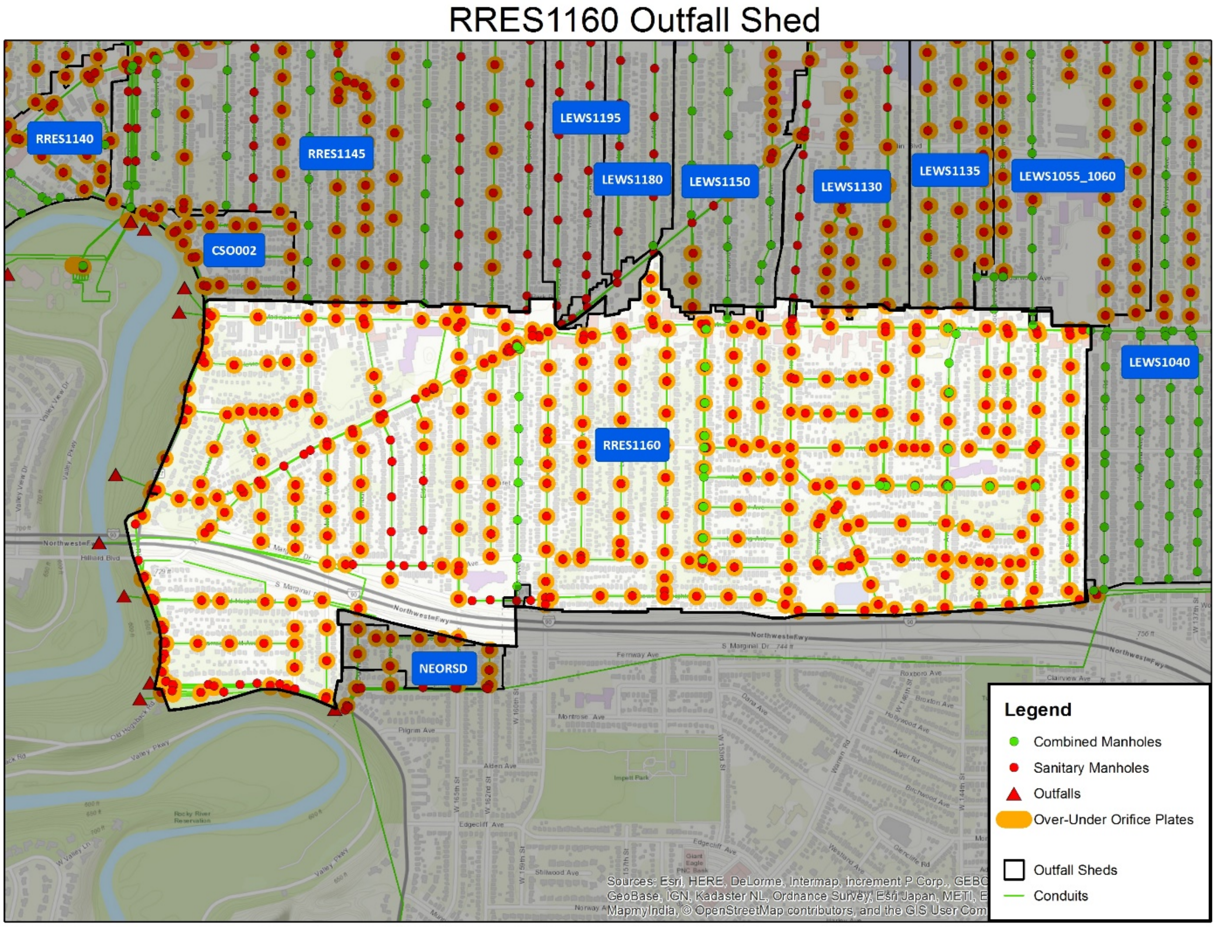


FIGURE 7-1. RRES 1160-1165 sewershed

7.2.2 Levels of Control Considered

RRES 1160-1165 is a permitted CSO, and therefore the following levels of control were evaluated; 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year storm analysis.

7.2.3 Alternatives Considered

The alternatives considered the level of control, the nature of control, and the technology whereby the control would be achieved. Level of control considered a range of outcomes from four to zero discharges per typical year, as well as controlling discharges in two-, five-, and 10-year storm events. Nature of control considered activation frequency reduction, volume reduction, total pollutant reduction, and sewage pollutant reduction. Technologies considered included end of pipe discharge alternatives, public system separation, public and private separation or source control, and tunnel storage for subsequent treatment at the WWTP.

Option A – Scalable and variable solutions

4/TY and 2/TY

Brown and Caldwell's technical memorandum dated February 28, 2019 (see Appendix 7-2) provides an evaluation of alternative concepts to address the discharges from CSO 052. The different approaches include a range of treatment and storage options over different discharge frequency conditions. It is assumed that each concept will be implemented at the treatment plant location. The area shown in Figure 7-2 directly to the east of the WWTP shows the area that is assumed to be available for these facilities. The currently planned ballasted flocculation (Acti-Flo) facility is shown.

FIGURE 7-2. Area for CSO 052 end of pipe solutions

Pollutant concentrations appear to be relatively low and may not be as amendable to higher levels of treatment using chemically enhanced approaches. These types of technologies may result in poorer performance when subjected to very dilute conditions. Additional sampling during wet weather would be necessary to address this concern. A number of CSO treatment approaches have been developed to more broadly assess the alternatives that would provide varying levels of treatment as outlined below.

- Actiflo (Ballasted Flocculation)
- Chemically Enhanced Primary Treatment (CEPT)
- Retention Treatment Basin (RTB)
- Screening and Disinfection
- Storage

For each treatment approach the facilities were sized to accommodate the second- through the fifth-largest events. Since each alternative includes a facility located on the east side of the WWTP, it is necessary to convey flow from CSO 052 to the site adjacent to the plant. Due to the much higher elevation of the CSO 052 outfall located across the Rocky River, an aerial sewer crossing was assumed for all alternatives.

Two approaches to storage were considered for this analysis including below- and above-ground. For each approach, flows would be directed into storage and, once full, flows would be diverted around storage and discharged without any treatment. The differences in storage approach relate to their costs of construction as well as the visibility of the storage tanks. Above-ground storage would be elevated above the ground surface from 20 to 40 feet depending on how it is constructed and sized. Following each wet-weather event, the stored flow is dewatered to the WWTP influent for full secondary treatment. The storage facility would include automatic flushing to remove solids captured during the basin filling process. This alternative would provide the simplest alternative to treatment since there are no disinfection facilities and resulting mechanical facilities to operate. Figure 7-3 depicts an example footprint associated with above ground storage. Three above-ground tanks with a total storage height of approximately 30 feet would be required.

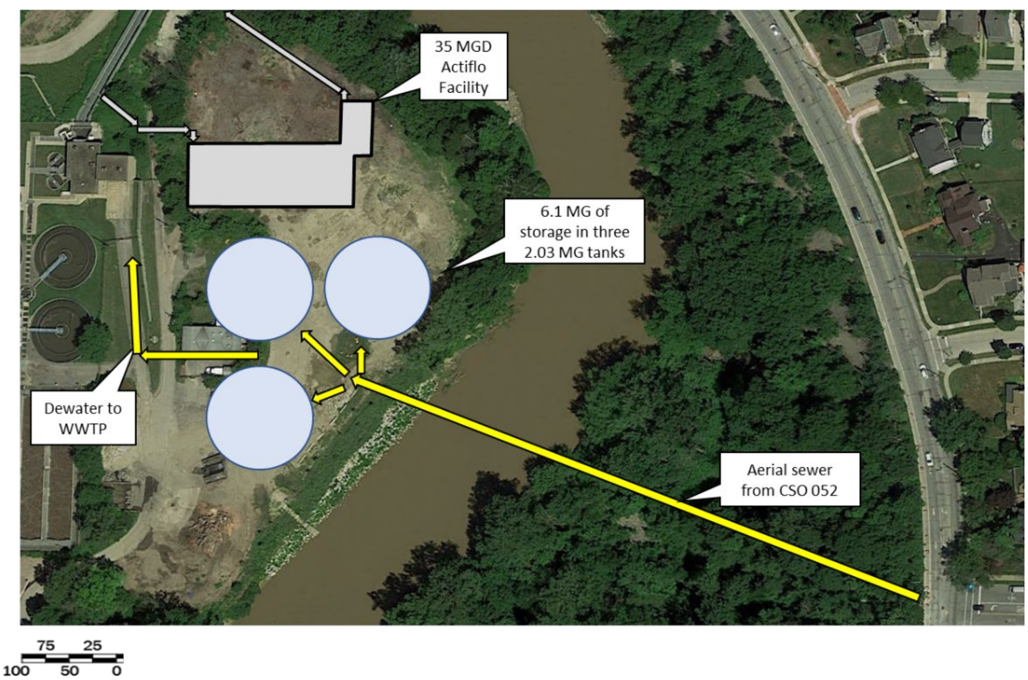


FIGURE 7-3. Layout of above-ground storage facility for CSO 052 discharges

The storage alternative results in the lowest TSS and CBOD pollutant loading discharged. This is due to the large storage volume that captures most of the CSO during the typical year and the capabilities of the WWTP. Storage is also significantly more cost-effective than any other alternative explored for this range of control objectives. As a result, for the IWWIP alternatives analysis the above-ground storage alternative is carried forward for the 4/TY and 3/TY levels of control. At higher levels of control (2/TY and beyond), significantly more storage would be required that may be difficult to construct on the WWTP property.

2/TY

The 2/TY solution set includes public system rehabilitation, relief sewers, and regulator modifications. Public system rehabilitation in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all impacted streets.

Public system rehabilitation would be performed on Richland, Brown and Athens north of Bayes, Ferndale, Baxterly, Marlowe (and Athens), Belle, Armin, Warren, Leonard, Arden, Esther, Lanning, Emily, Reveley, Elmwood, Arthur (south of Madison), Lakeland, Morrison, Delaware, Carabel, Northland, Woodward (south of Hilliard, plus Delaware and Eldred), Eldred, Glenbury (south of Hilliard), McKinley (south of Hilliard), Niagara, Concord, Hilliard, Indianola, Woodward (north of Hilliard), Atkins (north of Hilliard), McKinley (north of Hilliard), Riverway, Madison, Riverside, Arthur (north of Madison), Overbrook, Daleview, Lakewood Heights, and Narragansett. A total of 295 manholes would be separated, and 72,900 LF of sewer would be lined. Public laterals would be replaced on approximately 2,248 properties and P-traps replaced with a test tee.

The RRES 1160-1165 sewershed includes the source control pilot study project area (102 homes) which has already undergone public and private property source control.

Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity. The following relief sewers are included on local side streets in the two-year solution set:

TABLE 7-1. RRES 1160-1165 two-year solution set local relief sewers

STREET	DIAMETER	LENGTH (LF)
Richland Avenue	12-inch	1,842
Madison Avenue	12-inch	1,132
Carabel Avenue & Lakewood Heights Boulevard	12-inch	6,327
Northland Avenue	12-inch	1,837
Woodward Avenue	12-inch	2,267
Eldred Avenue	12-inch	1,238
Atkins Avenue	12-inch	1,669
Glenbury Avenue	12-inch	1,148
McKinley Avenue	12-inch	1,310
Hilliard Road	36-inch	1,816
Hilliard Road	12-inch	797

The additional flow will be conveyed to a relief sewer on Madison Avenue and Riverside Drive. The relief sewer would be approximately 8,500 LF and run parallel to the existing Madison Avenue under sewer with connections at each local street sewer connection (those streets connecting to the Madison Avenue system from the south), including the combined sewer areas.

In the single-pipe combined-sewer areas (Mars and Athens, Arden, Esther, Lanning, and Delaware), the connection to the over sewer would be reconnected to the under sewer only after the Madison relief sewer was constructed. Twelve manholes would also have to be separated in the project area.

On Olive, sewers would be separated, and a new 18-inch storm sewer (2,259 LF) would connect to the over sewer along Madison Avenue. The existing combined sewer would be reconnected to the under sewer only after the Madison relief sewer was constructed.

On Lincoln (and Bayes, Garfield, Delaware, Lakewood Heights, Adeline, and Hilda), a new 36-inch storm sewer would be provided extending approximately 363 feet upstream from Madison. The combined sewer connection at Madison would be reconnected to the under pipe only after the Madison relief sewer was constructed. Manhole separation would be necessary on 27 manholes in this project area. Additionally, approximately 4,136 LF of relief sewer would be needed in the Lincoln project area. These relief sewers are in addition to those already stated within this level of control solution.

1/TY and 0/TY
The same conditions were applied as those in the 2/TY scenario. The only difference is a slight increase in the amount of relief sewer needed for higher levels of control.

Two-year, five-year, and 10-year
Full public and private property source control was used to achieve these level of controls. This included the same 295 manholes separated and 72,900 LF of sewer lined. For the 2,248 properties to be addressed, private property source control would complement the public lateral lining and P-trap replacement. This would include lining of the sanitary lateral and re-building private property stormwater conveyance to the right of way.

The same combined area improvements were made as in the lesser levels of control, and the Madison-Riverside relief sewer was still needed. However, no local side street relief sewers were necessary since full source control was employed.

Option B – The Madison West tunnel

The Madison West tunnel is an 8,000 LF conveyance/storage tunnel that runs the length of Madison Avenue between Richland Avenue and Riverside Drive, basically mirroring the extents of the over-under sewer on Madison Avenue. The under sewer or combined sewer on each intersecting street is redirected to the conveyance or storage tunnel. The storm sewer from each intersecting street remains connected to the Madison Avenue storm sewer.

The properties along Madison Avenue remain connected to the under sewer on the Madison over-under sewer. Modeling indicated that these remaining properties contributed enough flow that the sanitary sewer surcharged multiple times in a typical year. To address the surcharging, the under sewer on Madison was connected to the conveyance or storage tunnel at each separated sanitary sewer manhole. Some surcharging remains in the largest volume storm during a typical year, but the freeboard remains greater than six feet.

The downstream end of the tunnel has a 12-inch drain line that is always open, ensuring that the tunnel drains fully between events. The 12-inch line runs north along Riverside Drive and connects (drops) into the interceptor at West Clifton.

The downstream end of the tunnel also has a 24-inch overflow with its invert matching the crown of the tunnel. The overflow discharges to the storm manhole 052T003 which is the upstream end of the storm outfall to RRES 1160.

The depth of the tunnel is arbitrary, but was placed deep enough so that it is hydraulically isolated from the local sewers. When the tunnel is full and is overflowing, it still does not impact the local sewers as the hydraulic grade line never rises high enough to reach the inverts of the connecting sewers.

To ensure the storm sewers have runoff only from the public right of way, approximately 2,200 manholes would need to be separated for all streets within the sewershed.

There is no private property source control on the over-under sewered streets included with this option nor is any green infrastructure included for streets with combined sewers. Therefore, relief sewers are needed to mitigate potential basement flooding. The relief sewers are located on side streets and are directly connected to the conveyance or storage tunnel. Consequently, there are drop structures at most intersections along Madison Avenue.

Relief sewers included with all options are as follows (Table 7-2):

TABLE 7-2. Relief sewers included with all RRES 1160-1165 tunnel options

ITEM	LENGTH (LF)
Relief sewers: 12-inch diameter	15,186
Relief sewers: 24-inch diameter	2,675
Relief sewers: 36-inch diameter	5,051

Pipe sizes within the tunnel vary with level of control are as follows:

- The 4/TY storm requires a 7-foot diameter pipe.
- The 3/TY storm requires an 8-foot diameter pipe.
- The 2/TY storm requires an 8-foot diameter pipe.
- The 1/TY storm requires a 10-foot diameter pipe.

- The 0/TY storm requires an 11-foot diameter pipe.
- The two-year storm requires a 10-foot diameter pipe.
- The five-year storm requires an 11-foot diameter pipe.
- The 10-year storm requires an 11-foot diameter pipe.

The pipes are common available reinforced concrete pipe sizes. The next largest common pipe size was used to provide the required storage volume.

7.2.4 Construction Cost Analysis

The cost increases slightly with increased levels of control (from the 2/TY to 0/TY levels of control) due to additional relief sewer extent and/or upsizing to prevent high HGLs. Overall, the tunnel alternatives (Option B) are less cost-effective than the storage and source control alternatives (Option A).

TABLE 7-3. RRES 1160-1165 Solution set options and construction costs in million $

	A	B
4/Typical Year	$22.0	$81.4
	-6.1 MG storage and aerial sewer	-Madison West Tunnel
3/Typical Year	$23.0	$81.8
	-6.4 MG storage and aerial sewer	-Madison West Tunnel
2/Typical Year	$62.6	$95.3
	-Public System Rehab, Relief Sewer, Regulator Modifications	-Madison West Tunnel
1/Typical Year	$63.5	$101.5
	-Public System Rehab, Relief Sewer, Regulator Modifications	-Madison West Tunnel
0/Typical Year	$65.7	$132.4
	-Public System Rehab and/or Source Control, Relief Sewer, Regulator Modifications	-Madison West Tunnel
2-Year	$72.7	$120.9
	-Source Control, CS Separation, Relief Sewer, Regulator Modifications	-Madison West Tunnel
5-Year	$72.7	$132.4
	-Source Control, CS Separation, Relief Sewer, Regulator Modifications	-Madison West Tunnel
10-Year	$76.6	$138.2
	-Source Control, CS Separation, Relief Sewer, Regulator Modifications	-Madison West Tunnel

7.3 LEWS 1035 (CSO 059)

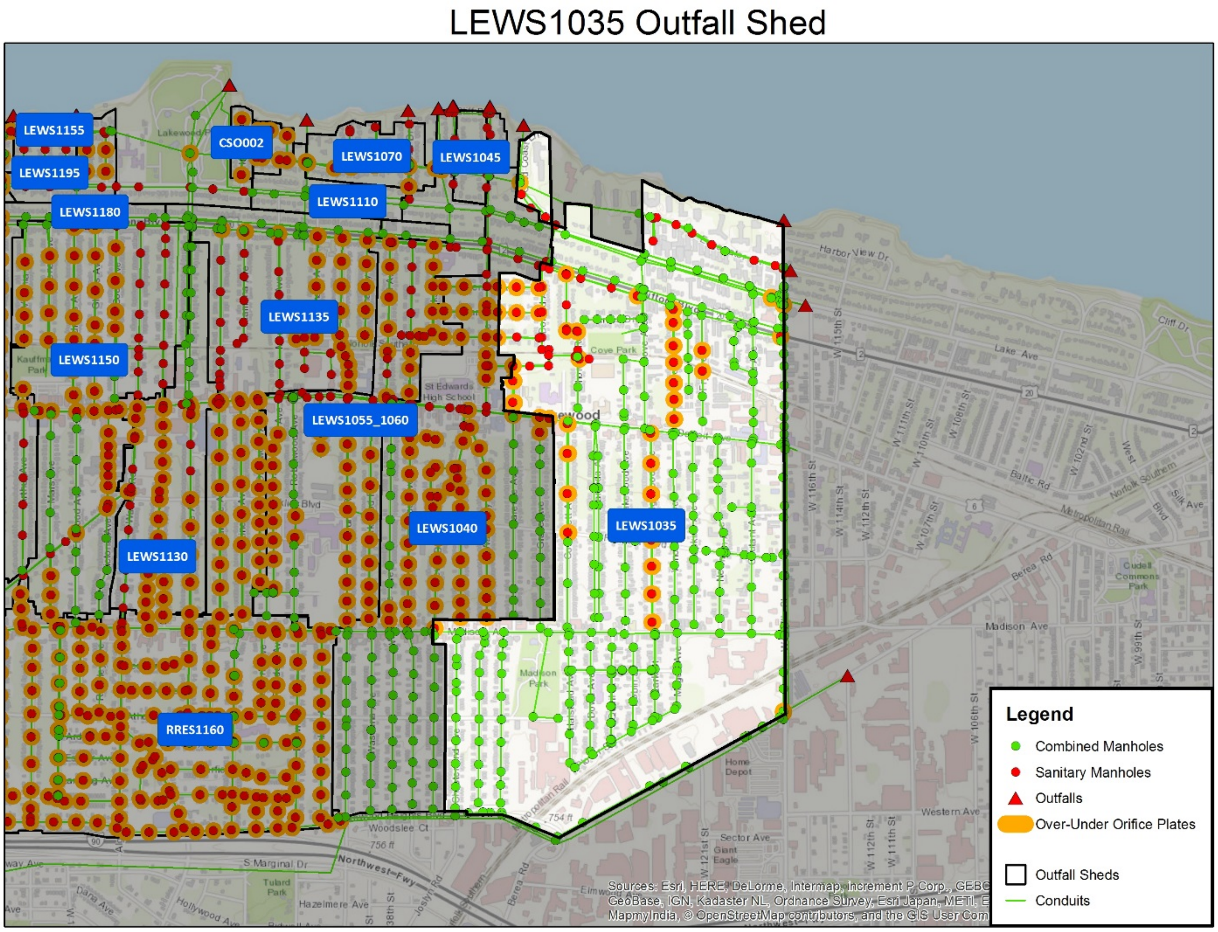


FIGURE 7-4. LEWS 1035 sewershed

7.3.2 Levels of Control Considered

LEWS 1035 is permitted as CSO 059, and therefore the following levels of control were evaluated; 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year storm analysis.

7.3.3 Alternatives Considered

Option A – HRT

An HRT was originally a concept for the east end "Gold Coast" area near CSO 059. However, due to limited overflow volumes, operational space footprint required, densely populated area with high rise structures and residential neighborhood character, storage became the preferred alternative. Therefore, the HRT concept was not tested using the model.

Option B – Storage

A storage facility is planned for the CSO 059 overflow. There are many variables included in the planning level costs for this alternative, including location of the facility. The concept is for a pump-in pump-out facility. This would require a diversion from the interceptor, or rerouting of flows from the CSO 059 existing overflow weir structure to a pump station. The facility would be placed as shallow as possible and be equipped with a 48-hour dewatering pump station to send detained flows back to the interceptor post-event.

The storage sizes required under existing conditions to achieve the various levels of control are as follows:

- 4/TY = 0.004 MG
- 3/TY = 0.198 MG
- 2/TY = 0.426 MG
- 1/TY = 0.739 MG
- 0/TY = 1.440 MG
- Two-year = 1.100 MG
- Five-year = 1.472 MG
- 10-year = 1.779 MG

7.3.4 Construction Cost Analysis

This alternative is largely dependent upon alternatives planned elsewhere in the system which deliver more or less flow to the interceptor. The permitted CSO 059 site is an interceptor relief combined sewer overflow. Additionally, during this screening process, a blanket cost of $4 per gallon was used to estimate costs. The unit costs used in composite solutions were increased significantly ($13-$18 per gallon plus siting contingencies) for this alternative due to perceived likely site constraints.

TABLE 7-4. LEWS 1035 solution set options and construction costs in million $

	A
4/Typical Year	$2.2
	-East End Storage
3/Typical Year	$2.9
	-East End Storage
2/Typical Year	$3.4
	-East End Storage
1/Typical Year	$5.0
	-East End Storage
0/Typical Year	$8.1
	-East End Storage
2-Year	$6.5
	-East End Storage
5-Year	$8.24
	-East End Storage
10-Year	$9.65
	-East End Storage

7.4 LEWS 1045

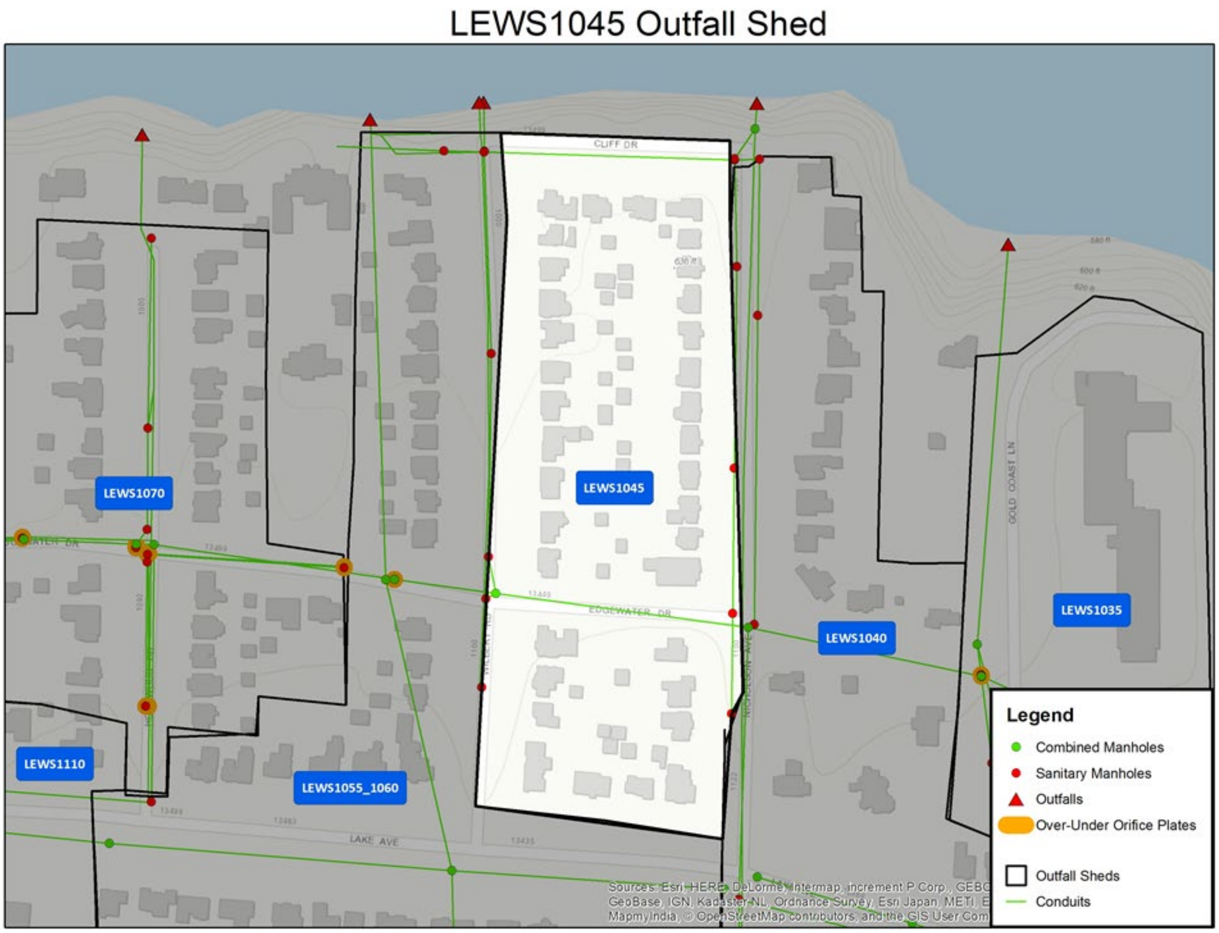


FIGURE 7-5. LEWS 1045 sewershed

7.4.2 Levels of Control Considered

LEWS 1045 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.4.3 Alternatives Considered

Option A – Pump station, weir modifications, relief sewers

Two-year

Due to the proximity of this sewershed to the interceptor, and the elevation of the basements of the homes within the sewershed in relation to the interceptor, only one alternative was considered. The LEWS 1045 solution set includes disconnecting (bulkheading) the local sanitary sewer from the interceptor, and providing a pump station to serve the local sewershed. By doing so, the pump will force discharge of the local flows to the interceptor and better protect the basements of the homes in the sewershed from backups due to risen interceptor HGLs.

To convey all flows to the pump station, approximately 478 LF of new 21-inch diameter sanitary sewer would convey flows to the pump station along Edgewater from Wilbert to Nicholson. A short (50-foot) stretch of force main would convey flows from the pump station to the interceptor. Additionally, modifications to the overflow weirs along Cliff will be made at both Nicholson and Wilbert, and approximately 1,196 LF of relief sewers are necessary along Cliff and Wilbert to convey flows to the pump station.

Five-year, and 10-year

The solution sets for the five-year and 10-year storms are the same, but costs increase slightly due to increased relief/sanitary sewer sizes.

7.4.4 Construction Cost Analysis

The solution effectively eliminates all sewage discharges under the storms scenarios analyzed.

TABLE 7-5. LEWS 1045 solution set options and construction costs in million $

	A
2-Year	$1.53
	-Bulkhead interceptor connection, add pump station to serve area
5-Year	$2.11
	-Bulkhead interceptor connection, add pump station to serve area
10-Year	$2.31
	-Bulkhead interceptor connection, add pump station to serve area

7.5 LEWS 1070

LEWS1070 Outfall Shed

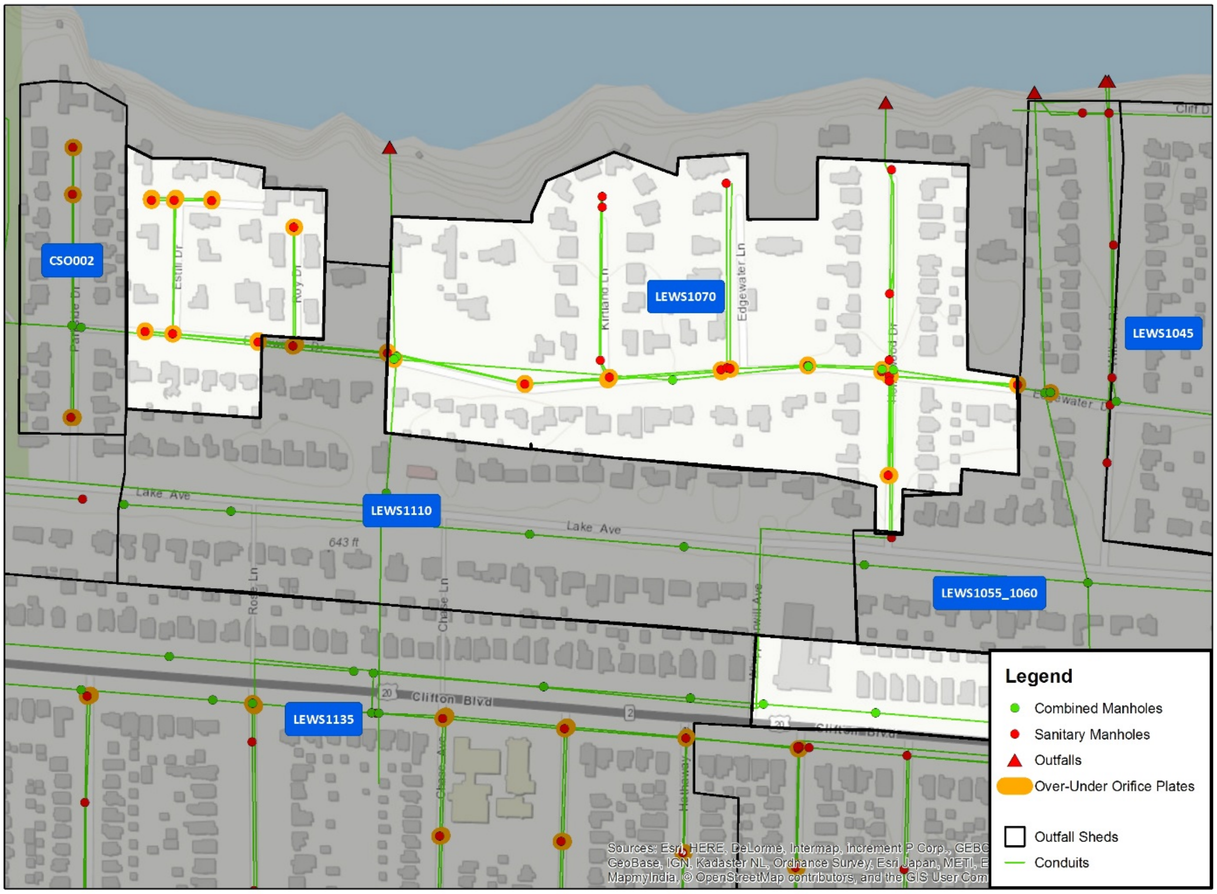


FIGURE 7-6. LEWS 1070 sewershed

7.5.2 Levels of Control Considered

LEWS 1070 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.5.3 Alternatives Considered

Option A – Diversion sewer, pump station, relief sewer

Two-year

The two-year solution set includes hydraulically separating (bulkheading) the existing connection to the interceptor, diverting local flows to a pump station, and relief sewers. The pump station would be located at Homewood Drive and Edgewater Drive. It would pump local flows into the interceptor on Edgewater Drive and prevent the interceptor from backing up through the existing connection pipe.

Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. Approximately 2,120 LF of relief sewer will be necessary along Clifton, Whippoorwill, Lake Avenue, and Homewood Drive.

Five-year, 10-year

The five-year and 10-year solution sets include the same recommendations as the two-year solution set with increased diameters for the relief sewer.

Option B – Source control, diversion sewer, pump station, storm sewer

Two-year

The two-year solution set includes hydraulically separating (bulkheading) the existing connection to the interceptor, and diverting local flows to a pump station, and performing full public and private property source control along Homewood at 22 homes. The pump station would pump local flows into the interceptor and prevent the interceptor from backing up through the existing connection pipe. Six catch basins would also need to be re-routed to a new 15-inch storm sewer approximately 900 LF long on Clifton east of Whippoorwill. The new storm sewer diameter would be 15-inches to meet the two-year LOS and 18-inches to meet the five-year and 10-year LOS.

Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system.

Five-year and 10-year

The five-year and 10-year solution sets include similar recommendations as the two-year solution set. The difference between the solution sets is an increase in the diameter of the new storm sewer from 15 inches to 18 inches.

7.5.4 CONSTRUCTION COST ANALYSIS

TABLE 7-6. LEWS 1070 solution set options and construction costs in million $

	A	B
2-Year	$1.62	$1.31
	Source Control, Diversion Sewer, Pump Station, relief sewer	Source Control, Diversion Sewer, Pump Station, storm sewer
5-Year	$1.66	$1.35
	Source Control, Diversion Sewer, Pump Station, relief sewer	Source Control, Diversion Sewer, Pump Station, storm sewer
10-Year	$1.70	$1.35
	Source Control, Diversion Sewer, Pump Station, relief sewer	Source Control, Diversion Sewer, Pump Station, storm sewer

Option B provides a slight cost savings.

7.6 RRES 1145

RRES1145 Outfall Shed

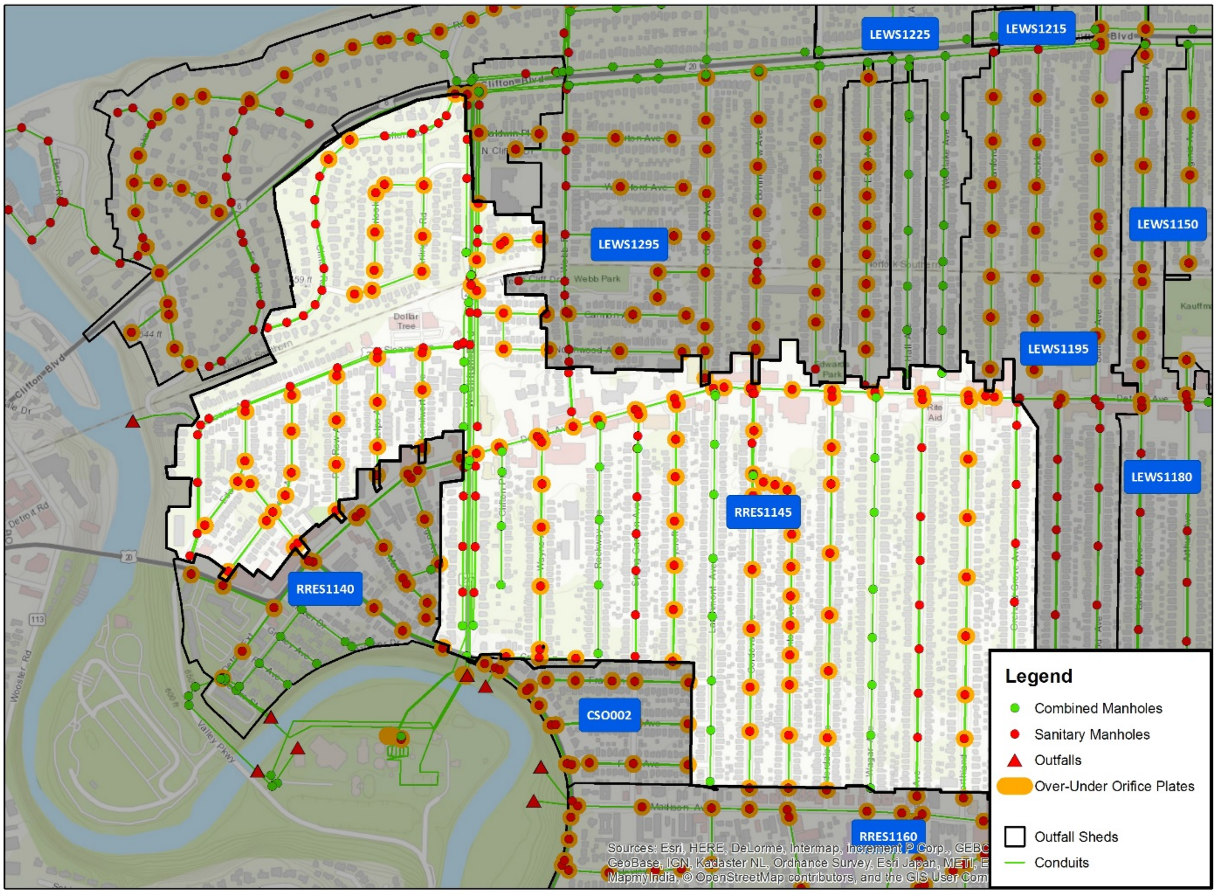


FIGURE 7-7. RRES 1145 sewershed

7.6.2 Levels of Control Considered

RRES 1145 is not a permitted CSO. The following levels of control were evaluated: two-year, five-year, and 10-year storms.

7.6.3 Alternatives Considered

Option A – Green infrastructure, source control and manhole separation

Two-year

On streets with over-under sewers the two-year storm solution set includes public system rehabilitation, private property rehabilitation, relief sewers, and regulator modifications. Public system rehabilitation includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps. Private property rehabilitation on these streets includes storm water source removal from the sanitary lateral and routing to the storm sewer system.

TABLE 7-7. Streets in RRES 1145 that may involve source control work.

STREET	MANHOLES SEPARATED	PIPES LINED WITH CIPP LINER (LF)	CONNECTIONS REHABILITATED
Shaw Ave	3	2393	12
Spring Garden	0	1686	70
Cannon/Northwood	4	1020	39
Matthews/Riverside	10	1909	57
Edanola	4	905	27
Park Row	3	968	39
Phelps	3	840	29
Kenilworth	3	680	27
Arlington/Overlook	9	2324	65
Clifton Ave	3	2436	54
Northland	9	822	100
Woodward	3	833	122
Lauderdale	10	826	125
Cordova/Winton	24	1705	225
Roycroft	8	545	75
Wayne/Crest	11	600	58

Public system rehabilitation in combined sewer areas includes green infrastructure development in the public right of way behind the street curb line. Private property rehabilitation in combined sewer areas includes storm water source removal from the sanitary lateral and routing to the green infrastructure system in the right of way.

TABLE 7-8. Streets in RRES 1145 that are single-pipe combined sewers.

STREET	ACRES TRIBUTARY TO GREEN INFRA-STRUCTURE	REPLACEMENT SEW-ER (SIZE-LF)
Wagar	16	0
Larchmont	14	0
Rockaway	6	0
Clifton Place	0	18" – 368 LF

Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging. The following streets have relief sewers for the two-year level of control;

TABLE 7-9. Relief sewers in RRES 1145 for two-year storm control

STREET	RELIEF SIZE (INCHES)	RELIEF LENGTH (LF)
Clifton Ave	12	240
Northland	18	401
Cordova/Winton - 1	18	306
Cordova/Winton - 2	30	391
Wayne/Crest	12	1450

Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers.

TABLE 7-10. Regulator modification in RRES 1145

REGULATOR	LOCATION	IMPROVEMENT
RRES 1145-W	West Clifton at Clifton	Raise weir to 2’ above storm invert
RRES 1145-O	West Clifton at RR tracks	Raise weir to 25.5’ above san invert
RRES 1145-G	West Clifton south of Detroit	Manhole Separation
RRES 1145-H	West Clifton south of Detroit	Manhole Separation
RRES 1145-S	West Clifton north of Shaw	Manhole Separation
RRES 1145-I	Clifton Place at Detroit	Manhole Separation

Five-year
Controls were the same as for a two-year with the following changes:

- On Clifton Avenue, the relief sewer length was increased from 240 feet to 431 feet
- On Cordova/Winton, the relief sewer sizes were increased from 18 and 30 inches to 21 and 36 inches
- On Wayne/Crest, 603 feet of the relief sewer size was increased from 12 inches to 18 inches

10-year
Controls were the same as for a five-year with the following changes:

- On Spring Garden, 592 feet of 24-inch relief sewer was added
- On Northland, the relief sewer size was increased from 18 inches to 24 inches
- On Wayne/Crest, the relief sewer size was increased in size from 18 inches to 24 inches and length from 603 feet to 654 feet

Option B – Storage tunnel

This tunnel is designed to capture overflows from the streets intersecting the Detroit Avenue sanitary sewer to eliminate pollutant loads to the storm sewer. The Detroit West tunnel is a 5,650 LF storage/conveyance tunnel that runs the length of Detroit Avenue between Elmwood Avenue and West Clifton Boulevard. The tunnel intercepts all under and combined sewer from the south. To ensure the storm sewers have only runoff from the public right of way approximately 194 manholes need to be separated. The storage tunnel is deep enough to be below all utilities and in suitable strata. Relief sewers are provided on side streets intersecting Detroit Avenue. The under sewer or combined sewer on each intersecting street is redirected to the conveyance/storage tunnel. The storm sewer from each intersecting street remains connected to the Detroit Avenue storm sewer.

This tunnel is designed to capture the sanitary flow from over-under streets and the underflow from regulators on combined streets intersecting Detroit Avenue to prevent migration of pollutants into the storm sewer on Detroit Avenue (which discharges through RRES 1145 and LEWS 1150). The intersecting streets where underflow is captured are:

- Clifton Place (RRES 1145-I) *
- Wayne
- Rockway (hydrobrake removed) (RRES 1145-J)*
- Spring Garden (RRES 1145-K)
- Roycroft
- Larchmont (RRES 1145-L) *
- Cordova
- Lauderdale
- Wagar (RRES 1145-M) *
- Woodward
- Northland
- Orchard Grove
- Rosewood
- Westwood
- Lakeland
- Arthur
- Mars (LEWS 1150-D) *
- Elmwood (LEWS 1150-C) *

** signifies single-pipe combined sewer streets with overflows.*

Note that Mars and Elmwood overflows are tributary to LEWS 1150 (CSO 056).

The properties along Detroit Avenue remain connected to the sanitary sewer on the over-under sewer. Modeling indicated that these remaining properties don't contribute enough flow to surcharge the sewer during a 10-year, two-hour rainfall event.

The downstream end of the tunnel has a 12-inch drain line that is always open. The 12-inch line connects (drops) into the interceptor at West Clifton Boulevard.

There is no overflow from the tunnel. Should the tunnel fill up beyond its capacity, the flow from the side streets will overflow to the storm sewer on Detroit at the remaining CSOs located at Clifton Place, Rockway, Larchmont, Wagar, Mars, and Elmwood.

The depth of the tunnel is arbitrary, but was placed deep enough so that it is hydraulically isolated from the local sewers during all events up to a 10-year, two-hour event.

There is no private property source control on the over-under streets included with this option nor is any green infrastructure included for streets with combined sewers. Therefore, relief sewers are needed to mitigate potential basement flooding. The relief sewers are located on side streets and are directly connected to the conveyance/storage tunnel. Consequently, there are drop structures at most intersections along Detroit Avenue.

TABLE 7-11. RRES 1145 Relief sewers included with all tunnel options

ITEM	LENGTH (LF)
Relief sewers: 12-inch diameter	3,798
Relief sewers: 36-inch diameter	1,261

Pipe sizes within the tunnel are as follows:

- The two- and five-year storm require a 7-foot diameter pipe
- The 10-year storm requires an 8-foot diameter pipe

The pipes are common available reinforced concrete pipe sizes. The next largest common pipe size was used to provide the required storage volume.

7.6.4 Construction Cost Analysis

TABLE 7-12. RRES 1145 solution set options and construction costs in million $

	A	B
2-Year	$30.0	$63.6
	-Source Control, Sewer Separation, Regulator Modification, Green Infra-structure	-Detroit West Tunnel
5-Year	$30.0	$63.6
	-Source Control, Sewer Separation, Regulator Modification, Green Infra-structure	-Detroit West Tunnel
10-Year	$30.4	$67.9
	-Source Control, Sewer Separation, Regulator Modification, Green Infra-structure	-Detroit West Tunnel

7.7 LEWS 1110 (CSO 058)

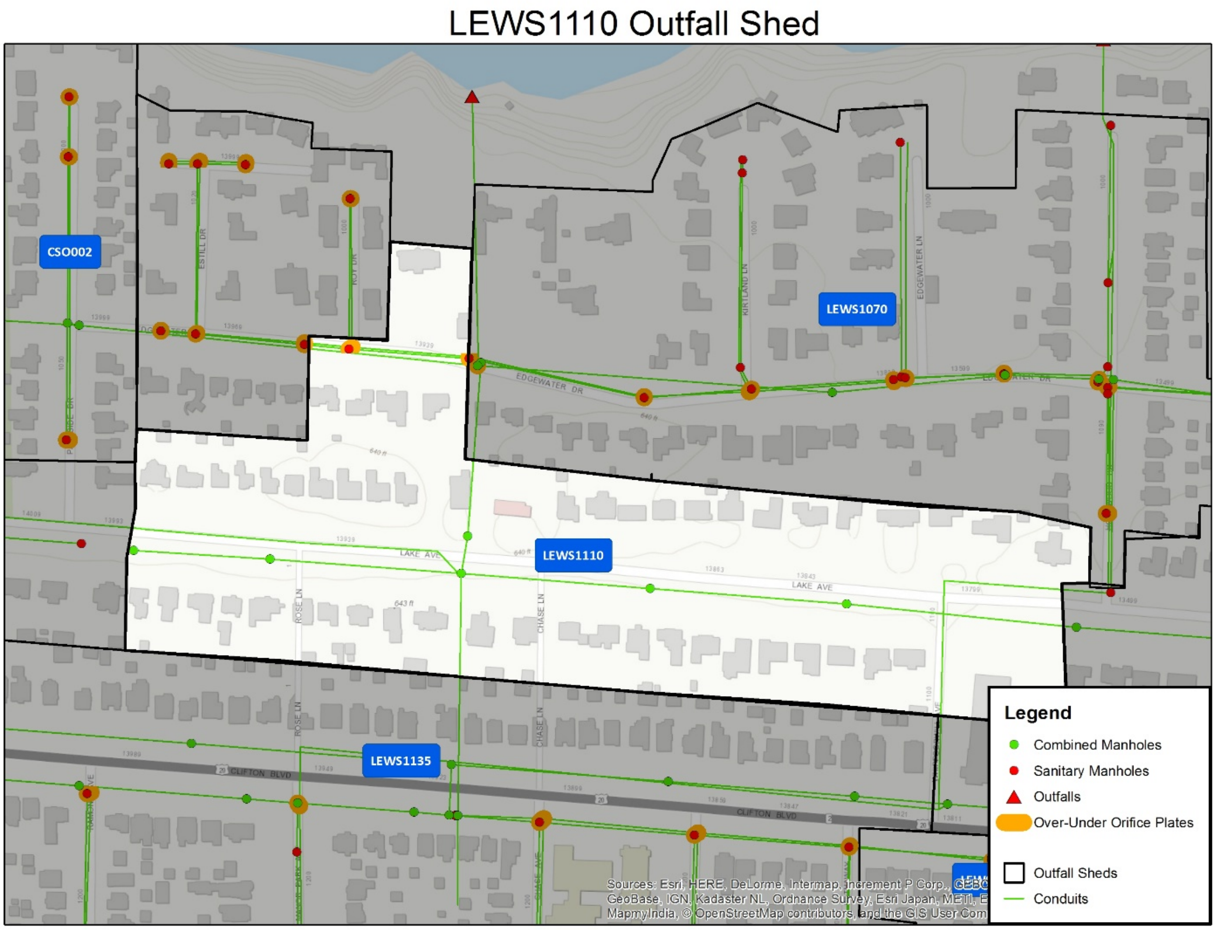


FIGURE 7-8. LEWS 1110 sewershed

7.7.2 Levels of Control Considered

LEWS 1110 is permitted as CSO 058, and therefore the following levels of control were evaluated; 0/TY, two-year, five-year, and 10-year storm analysis.

7.7.3 Alternatives Considered

The 2018 Lake Avenue resurfacing improvements project included a storm sewer diversion, which re-routes storm flow entering the LEWS 1110 sewershed from south of Lake Avenue to the LEWS 1130 outfall pipe through Lakewood Park. Monitoring data is being collected to confirm the impact of this project which was expected to reduce the occurrences and volume over the LEWS 1110 (CSO 058) weir. In addition to this completed project, the following control technologies were modeled.

Option A – Control technologies vary with level of control

4/TY, 3/TY, 2/TY, 1/TY

The 4/TY, 3/TY, 2/TY, 1/TY solution set includes a regulator modification, raising the overflow weir elevation by approximately 9 inches.

0/TY, two-year, five-year

The 0/TY, two-year, and five-year solution sets also include regulator modifications. Regulator modifications include raising the overflow weir elevation by approximately 9 inches and upsizing the connection from the regulator to the Interceptor from 8 inches to 12 inches (16 LF of 12-inch sewer).

10-year

The 10-year solution set includes regulator modifications. Regulator modifications include raising the overflow weir elevation by approximately 9 inches and upsizing the connection from the regulator to the Interceptor (16 LF of 24-inch sewer).

7.7.4 CONSTRUCTION COST ANALYSIS

TABLE 7-13. LEWS 1110 solution set options and construction costs in million $

	A
4/Typical Year	$0.0
	Diversion Sewer
3/Typical Year	$0.0
	Diversion Sewer
2/Typical Year	$0.0
	Diversion Sewer
1/Typical Year	$0.0
	Diversion Sewer
0/Typical Year	$0.1
	Diversion Sewer
2-Year	$0.1
	Diversion Sewer
5-Year	$0.1
	Diversion Sewer
10-Year	$0.1
	Diversion Sewer

This project is already planned and is currently in design for the five-year control as a part of the 2019 Regulator Modification project expected to be constructed in 2019.

7.8 LEWS 1150-1155 Solution Set Description

LEWS1150 Outfall Shed

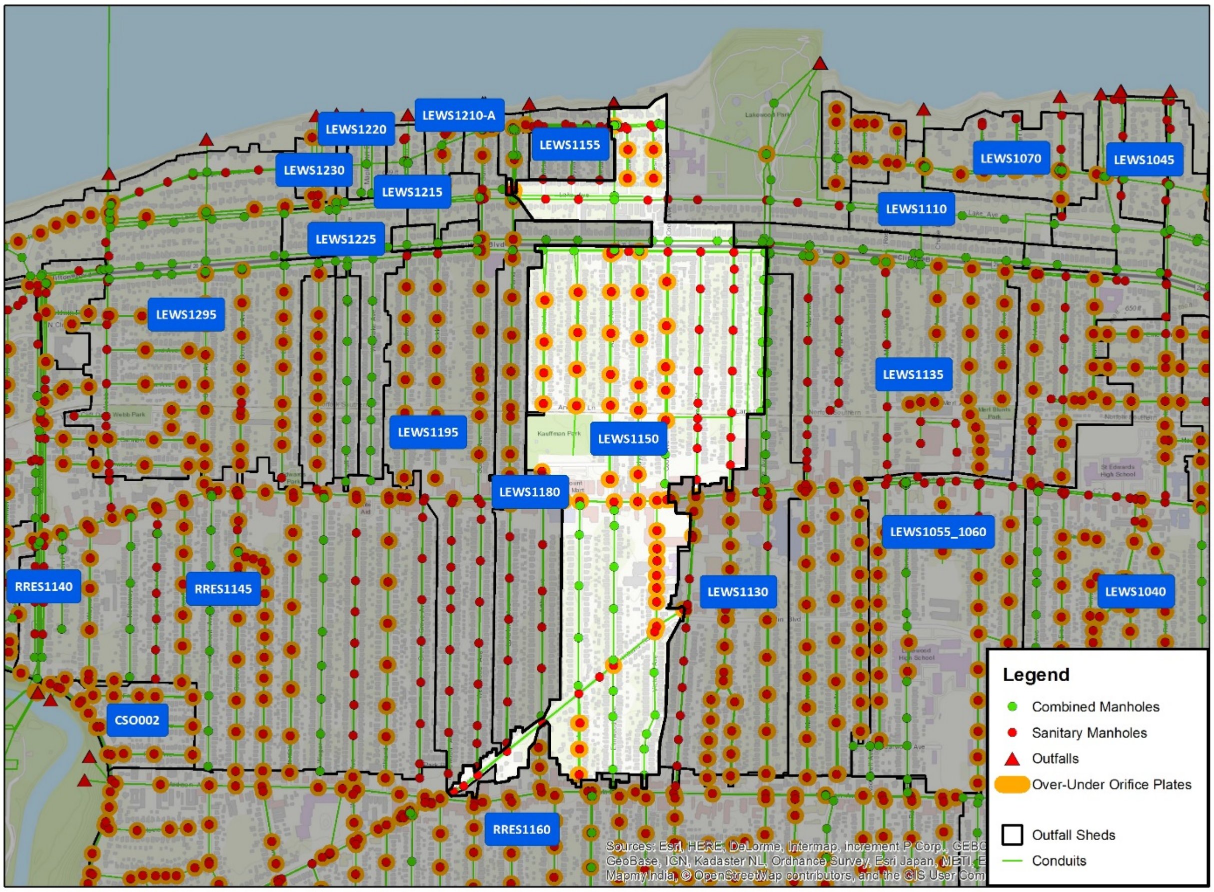


FIGURE 7-9. LEWS 1150 sewershed

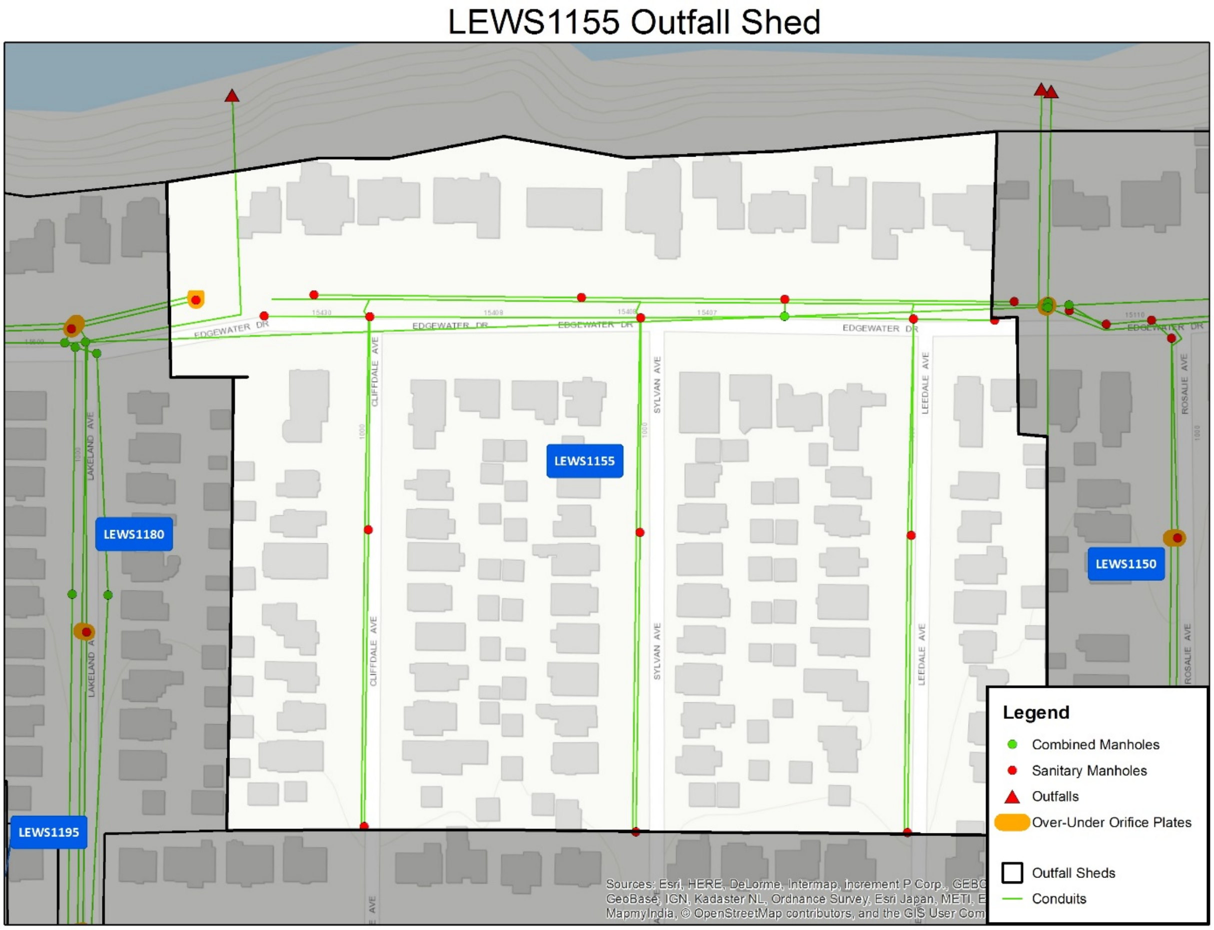


FIGURE 7-10. LEWS 1155 sewershed

7.8.2 Levels of Control Considered

LEWS 1150-1155 is a permitted CSO (CSO 056), and therefore the following levels of control were evaluated based upon the alternative reviewed as follows:

- Option A – Source Control, Green Infrastructure, Relief Sewers and Regulator Modifications with 0/TY, two-year, five-year, and 10-year storm analysis. The 4/TY, 3/TY, 2/TY, 1/TY solution was the same as Option A below, however it provides a 0/TY level of control.
- Option B – Tunnels with two-year, five-year, and 10-year storm analysis.

7.8.3 Alternatives Considered

Option A – Source control, green infrastructure, pump station, relief sewer, regulator modifications

Option A solutions considered public and private property solutions. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab.

Public system rehab in combined sewer areas includes green infrastructure development in the public right of way behind the street curb line.

Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. Private property rehab in combined sewer areas includes storm water source removal from the sanitary lateral and routing to the green infrastructure system in the right of way.

Public solutions also comprise of a new sewer, pump station and regulator modifications. The relief sewer will provide relief to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers.

0/TY

The typical year event with 0 overflow solution set includes public system rehab, private property rehab, relief sewers, pump station, and regulator modifications.

Private system rehab would be performed on Hilliard Road (Mars Avenue to Victoria Avenue).

Public system rehab would be performed on Edgewater Drive (Lakeland Avenue to Abbieshire Drive) and Detroit Avenue (Mars Avenue to Cook Avenue).

Public and private system rehab would be performed Rosalie Avenue, Abbieshire Avenue, Clifton Boulevard (Andrews Avenue to Belle Avenue), Gladys Avenue, Cook Avenue (Detroit Avenue to Clifton Boulevard), Warren Road (Detroit Avenue to Clifton Boulevard), St Charles Avenue (Detroit Avenue to Clifton Boulevard), Belle Avenue (Railroad Tracks to Clifton Boulevard), Hilliard Road (Madison Avenue to Victoria Avenue), Mars Avenue (Madison Avenue to Detroit Avenue), Elmwood Avenue (Madison Avenue to Detroit Avenue), and Victoria Avenue (Madison Avenue to Detroit Avenue).

A total of 38 manholes would be separated, and 12,669 LF of sewer would be lined. Private laterals on approximately 820 properties would have laterals lined to the right of way and P-traps replaced with a test tee. Green infrastructure is provided on Mars Avenue, Elmwood Avenue, Victoria Avenue and Cook Avenue (south of the Railroad Tracks) for approximately 35 acres of tributary area properties.

TABLE 7-14. LEWS 1150-1155 Option A Relief sewers required for 0/TY

STREET	ITEM	DIAMETER	LENGTH (LF)
Rosalie Avenue (Lake Avenue to Edgewater Drive)	Sanitary Sewer	15"dia	1,200

A pump station is recommended on Edgewater Drive (between Leedale Avenue and Sylvan Avenue). The pump station will convey sanitary flow from the existing sanitary sewer and relief sewer to the Interceptor.

Additionally, modifications were made to regulators LEWS 1155, LEWS 1150, LEWS 1150A, LEWS 1150B, LEWS 1150C, LEWS 1150D, and LEWS 1150E.

Two-year

The two-year solution set includes public system rehab, private property rehab, relief sewers, pump station, and regulator modifications. The solution set mimics the 0/TY solution set with the addition of more relief sewers:

TABLE 7-15. LEWS 1150-1155 Option A Relief sewers required for two-year

STREET	ITEM	DIAMETER	LENGTH (LF)
Detroit Avenue (Elmwood Avenue to West Clifton Boulevard)	Relief Sewer	24” dia	5,640
Elmwood Avenue (Easement to Detroit Avenue)	Relief Sewer	12” dia	808
Easement between Victoria Avenue and Elmwood Avenue	Relief Sewer	12”dia	417
Victoria Avenue (Hilliard Road to Easement)	Relief Sewer	12” dia	435
Belle Avenue (Clifton Boulevard to Interceptor)	Relief Sewer	21” dia	957
Cooke Avenue (Proposed GI to Existing Storm Sewer)	Relief Sewer	12” dia	346

Five-year

The five-year solution set includes public system rehab, private property rehab, relief sewers, pump station, and regulator modifications. The solution set mimics the two-year solution set except the Detroit Avenue and Belle Avenue relief sewers are upsized and additional relief sewers are needed.

TABLE 7-16. LEWS 1150-1155 Option A Relief sewers required for five-year

STREET	ITEM	DIAMETER	LENGTH (LF)
Belle Avenue (Proposed GI to Clifton Boulevard)	Relief Sewer	12” dia	315
Clifton Boulevard (Proposed GI n/o Virginia Avenue to Lakeland Avenue)	Relief Sewer	15” dia	329

10-year

The 10-year solution set includes public system rehab, private property rehab, relief sewers, pump station, and regulator modifications. The solution set mimics the five-year solution set except the Detroit Avenue and Belle Avenue and upstream relief sewers are upsized and additional relief sewers are needed:

TABLE 7-17. LEWS 1150-1155 Option A Relief sewers required for five-year

STREET	ITEM	DIAMETER	LENGTH (LF)
Detroit Avenue (Gladys Avenue to West Clifton Boulevard)	Relief Sewer	30” dia	5,850
Elmwood Avenue (Easement to Detroit Avenue)	Relief Sewer	15” dia	808
Easement between Victoria Avenue and Elmwood Avenue	Relief Sewer	15”dia	417
Victoria Avenue (Hilliard Road to Easement)	Relief Sewer	15” dia	435
Clifton Boulevard (Proposed GI n/o Virginia Avenue to Lakeland Avenue	Relief Sewer	21” dia	329
Cook Avenue to Virginia Avenue)	Relief Sewer	18” dia	1,152

Option B – Detroit West tunnel

This Detroit West tunnel is designed to capture overflows from the streets intersecting the Detroit Avenue sanitary sewer to eliminate pollutant loads to the storm sewer to reduce or eliminate discharge of pollutants at RRES 1145 and LEWS 1150. The tunnel is a 5,650 LF storage/conveyance tunnel that runs the length of Detroit Avenue between Elmwood Avenue and West Clifton Boulevard. The tunnel intercepts all sanitary and combined sewer from the south. To insure the storm sewers have only runoff from the public right of way, manholes (approximately 194) need to be separated for all streets within the sewershed. The storage tunnel is deep enough to be below all utilities and in suitable strata. Relief sewers are provided on side streets intersecting Detroit Avenue. The sanitary sewer or combined sewer on each intersecting street is redirected to the conveyance/storage tunnel. The storm sewer from each intersecting street remains connected to the Detroit Avenue Storm Sewer.

This tunnel is designed to capture the sanitary flow from over-under streets and the underflow from regulators on combined streets intersecting Detroit Avenue to prevent migration of pollutants into the storm sewer on Detroit Avenue (which discharges through RRES 1145 and LEWS 1150). The intersecting streets where underflow is captured are (in west to east order):

- Clifton Place (RRES 1145-I) *
- Wayne
- Rockway (hydrobrake removed) (RRES 1145-J)*
- Spring Garden (RRES 1145-K)
- Roycroft
- Larchmont Avenue (RRES 1145-L) *
- Cordova Avenue
- Lauderdale Avenue
- Wagar Avenue (RRES 1145-M) *
- Woodward Avenue
- Northland Avenue
- Orchard Grove Avenue
- Rosewood Avenue
- Westwood Avenue
- Lakeland Avenue

- Arthur Avenue
- Mars Avenue (LEWS 1150-D) *
- Elmwood Avenue (LEWS 1150-C) *

** signifies combined sewer streets with overflows.*

Note that Mars Avenue and Elmwood Avenue overflows are tributary to LEWS 1150 (CSO 056).

The properties along Detroit Avenue remain connected to the sanitary sewer on the over-under sewer. Modeling indicated that these remaining properties don't contributed enough flow to surcharge the sewer during a 10-year rainfall event.

The downstream end of the tunnel has a 12-inch drain line that is always open that drains the tunnel between rain events. The 12-inch line connects (drops) into the interceptor at West Clifton Boulevard.

There is no overflow in the tunnel. Should the tunnel fill up beyond its capacity, the flow from the side streets will overflow to the storm sewer on Detroit Avenue at the remaining CSOs located at Clifton Place, Rockway Avenue, Larchmont Avenue, Wagar Avenue, Mars Avenue, and Elmwood Avenue.

The depth of the tunnel is arbitrary, but was placed deep enough so that it is hydraulically isolated from the local sewers during all events up to a 10-year rainfall event.

There is no private property source control on the over-under sewered streets included with this option nor is any green infrastructure included for streets with combined sewers. Therefore, relief sewers are needed to mitigate potential basement flooding. The relief sewers are located on side streets and are directly connected to the conveyance/storage tunnel. Consequently, there are drop structures at most intersections along Detroit Avenue.

TABLE 7-18. Relief sewers included with all Detroit West tunnel options

ITEM	LENGTH (LF)
Relief sewers: 12-inch diameter	3,798
Relief sewers: 36-inch diameter	1,261

Pipe sizes within the tunnel vary with level of control are as follows:

- The two-year storm requires a 7-foot diameter pipe.
- The five-year storm requires a 7-foot diameter pipe.
- The 10-year storm requires an 8-foot diameter pipe.

7.8.4 Construction Cost Analysis

TABLE 7-19. LEWS 1150-1155 solution set options and construction costs in million $

	A	B
4/Typical Year	$18.3	
	-Source Control, GI, Relief Sewer, Regulator Modifications	
3/Typical Year	$18.3	
	-Source Control, GI, Relief Sewer, Regulator Modifications	
2/Typical Year	$18.3	
	-Source Control, GI, Relief Sewer, Regulator Modifications	
1/Typical Year	$18.3	
	-Source Control, GI, Relief Sewer, Regulator Modifications	
0/Typical Year	$18.3	
	-Source Control, GI, Relief Sewer, Regulator Modifications	
2-Year	$23.3	Incl w/RRES 1145
	-Source Control, GI, Relief Sewer, Regulator Modifications	-Detroit West Tunnel
5-Year	$24.0	-Detroit West Tunnel
	-Source Control, GI, Relief Sewer, Regulator Modifications	-Detroit West Tunnel
10-Year	$25.2	-Detroit West Tunnel
	-Source Control, GI, Relief Sewer, Regulator Modifications	-Detroit West Tunnel

Option A solution sets provide similar overflow volumes for each LOS and sends less storm-water flow to the plant.

7.9 LEWS 1130-1135 (CSO 057)

LEWS1130 & LEWS1135 Outfall Shed

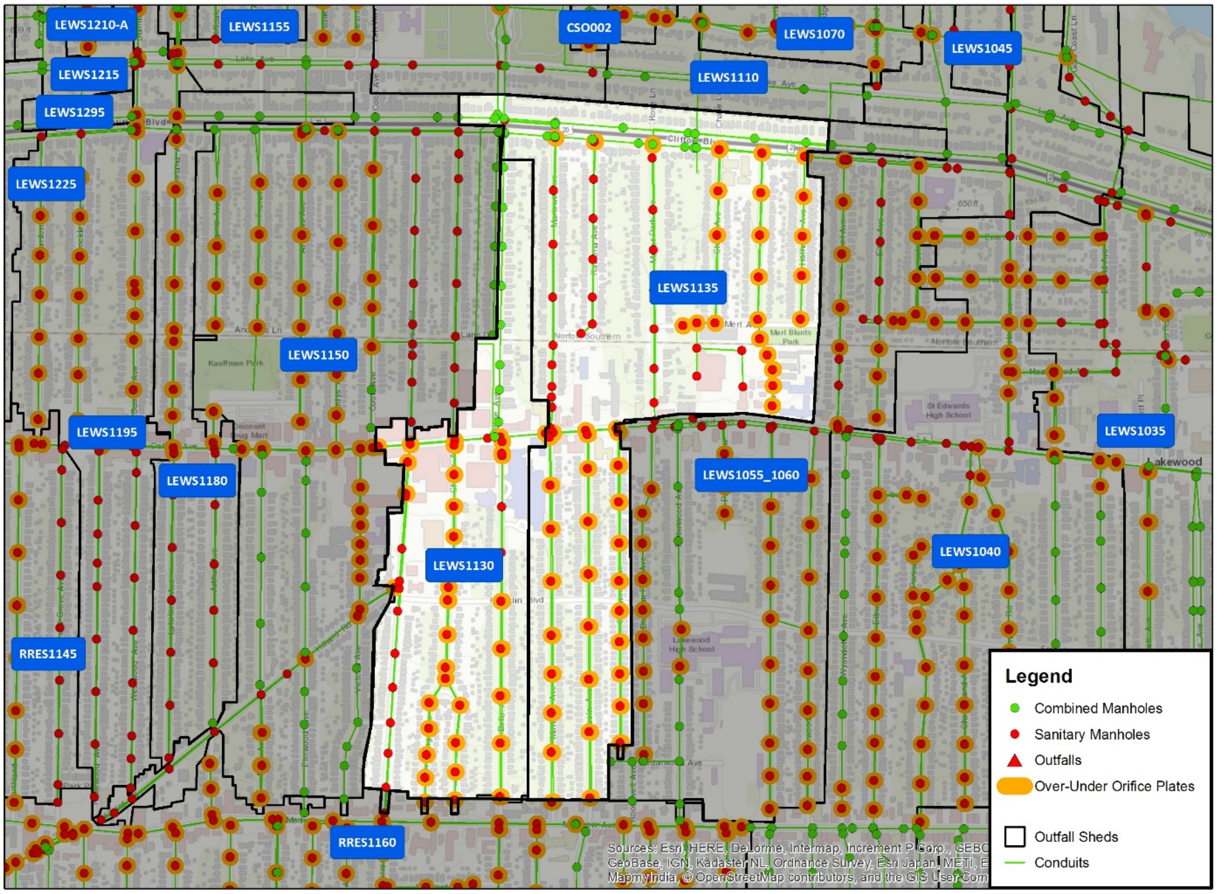


FIGURE 7-11. LEWS 1130-1135 sewersheds

7.9.2 Levels of Control Considered

LEWS 1135 is permitted as CSO 057, and therefore the following levels of control were evaluated; 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year storm analysis.

7.9.3 Alternatives Considered

Option A – Storage

This option is to capture overflows from the CSO at the southeast corner of Belle Avenue and Clifton Boulevard and the CSO in Lakewood Park at the interceptor. The option is intended to eliminate pollutant loads to the storm sewer that discharges at the LEWS 1130 outfall and eliminate discharges from CSO 057 to the LEWS 1135 outfall. The Belle portion of this option is a 665 LF storage/conveyance tunnel that runs within Belle Avenue from Clifton Boulevard north into Lakewood Park. The regulator overflow at the southeast corner of Belle and Clifton is redirected away from the storm sewer that connects to the LEWS 1130 outfall and is routed to the tunnel which outlets to the interceptor. To insure the storm sewers have only runoff from the public right of way, manholes (approximately 368) need to be separated for all streets within the sewershed.

The overflow from the Lakewood Park regulator operates independently of the Belle Avenue regulator and therefore has a separate reaction to rainfall. This part of this option involves a storage tank that intercepts any overflow before it is discharges to outfall LEWS 1135. The storage tank is a gravity-in, pump-out design with the pumps sized to dewater the tank within 24 hours after a rainfall event. The dewatering pumps discharge to the interceptor.

There is no private property source control on the over-under sewered streets included with this option nor is any green infrastructure included for streets with combined sewers. No relief sewers are provided since there is no place for the relief sewers to discharge unless a storage/conveyance tunnel was also constructed on Clifton Boulevard. To grab flow from relief sewers within the tunnel option was judged to be not feasible due to cost increases.

Pipe sizes within the tunnel vary with level of control are as follows:

- The 4/TY storm requires an 8-inch diameter pipe (conveyance).
- The 3/TY storm requires an 8-inch diameter pipe (conveyance).
- The 2/TY storm requires an 8-inch diameter pipe (conveyance).
- The 1/TY storm requires an 18-inch diameter pipe (conveyance and storage).
- The 0/TY storm requires a 21-inch diameter pipe (conveyance and storage).
- The two-year storm requires a 3-foot diameter pipe (conveyance and storage).
- The five-year storm requires a 6-foot diameter pipe (conveyance and storage).
- The 10-year storm requires a 10-foot diameter pipe (conveyance and storage).

The pipes are common available reinforced concrete pipe sizes. The next largest common pipe size was used to provide the required storage volume.

Storage tank sizes vary with level of control area as follows:

- The 4/TY storm requires a 0.010 MGal tank.
- The 3/TY storm requires a 0.069 MGal tank.
- The 2/TY storm requires a 0.071 MGal tank.
- The 1/TY storm requires a 0.182 MGal tank.
- The 0/TY storm requires a 0.242 MGal tank.
- The two-year storm requires a 0.302 MGal tank.
- The five-year storm requires a 0.372 MGal tank.
- The 10-year storm requires a 0.417 MGal tank.

Option B – Source control, green infrastructure, regulator modifications

0/TY and two-year

The 0/TY and two-year solution sets include full public and private source control, green infrastructure, and regulator modifications.

Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Public system rehab in combined sewer areas includes green infrastructure development in the public right of way behind the street curb line.

Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. Private property rehab in combined sewer areas includes storm water source removal from the sanitary lateral and routing to the green infrastructure system in the right of way.

Source control would be completed on the following streets; Olivewood, Lincoln, Marlowe, Belle, St. Charles, Onondaga, Warren, Detroit, Hathaway, Bunts, Chase, Manor Park, Ramona, Clifton, Geil, Elbur, Merl, and Jackson. Source control would include approximately 113 manhole separations and 1,233 properties.

Green infrastructure would receive runoff from approximately 33 acres of contributory sewershed along Clifton Drive and Belle Avenue.

Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers. The regulator modification would be to raise the existing weir at CSO 057 to approximately 2.76 feet from the manhole invert.

Five-year and 10-year

The five-year and 10-year solution sets include full public and private source control, relief sewers and regulator modifications. The public and private source control and regulator modifications follow the recommendation outlined in the 0/TY and two-year solutions sets.

Relief sewers include parallel sewers to the existing under or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. The 10-year solution set recommends approximately 925 LF of relief sewer along Clifton Drive.

7.9.4 Construction Cost Analysis

TABLE 7-20. LEWS 1130-1135 solution set options and construction costs in million $

	A	B
4/Typical Year	$14.4	
	-Belle Storage Tunnel, Lakewood Park Storage Basin	
3/Typical Year	$15.1	
	-Belle Storage Tunnel, Lakewood Park Storage Basin	
2/Typical Year	$15.1	
	-Belle Storage Tunnel, Lakewood Park Storage Basin	
1/Typical Year	$16.7	
	-Belle Storage Tunnel, Lakewood Park Storage Basin	
0/Typical Year	$17.3	$30.1
	-Belle Storage Tunnel, Lakewood Park Storage Basin	-Source Control, GI, Relief Sewer, Regulator Modifications
2-Year	$18.7	$30.1
	-Belle Storage Tunnel, Lakewood Park Storage Basin	-Source Control, GI, Relief Sewer, Regulator Modifications
5-Year	$18.7	$30.6
	-Belle Storage Tunnel, Lakewood Park Storage Basin	-Source Control, GI, Relief Sewer, Regulator Modifications
10-Year	$23.1	$30.6
	-Belle Storage Tunnel, Lakewood Park Storage Basin	-Source Control, GI, Relief Sewer, Regulator Modifications

Both scenarios send stormwater only flow to the LEWS 1130 outfall. The storage option A is the cost-effective alternative.

7.10 LEWS 1040

LEWS1040 Outfall Shed

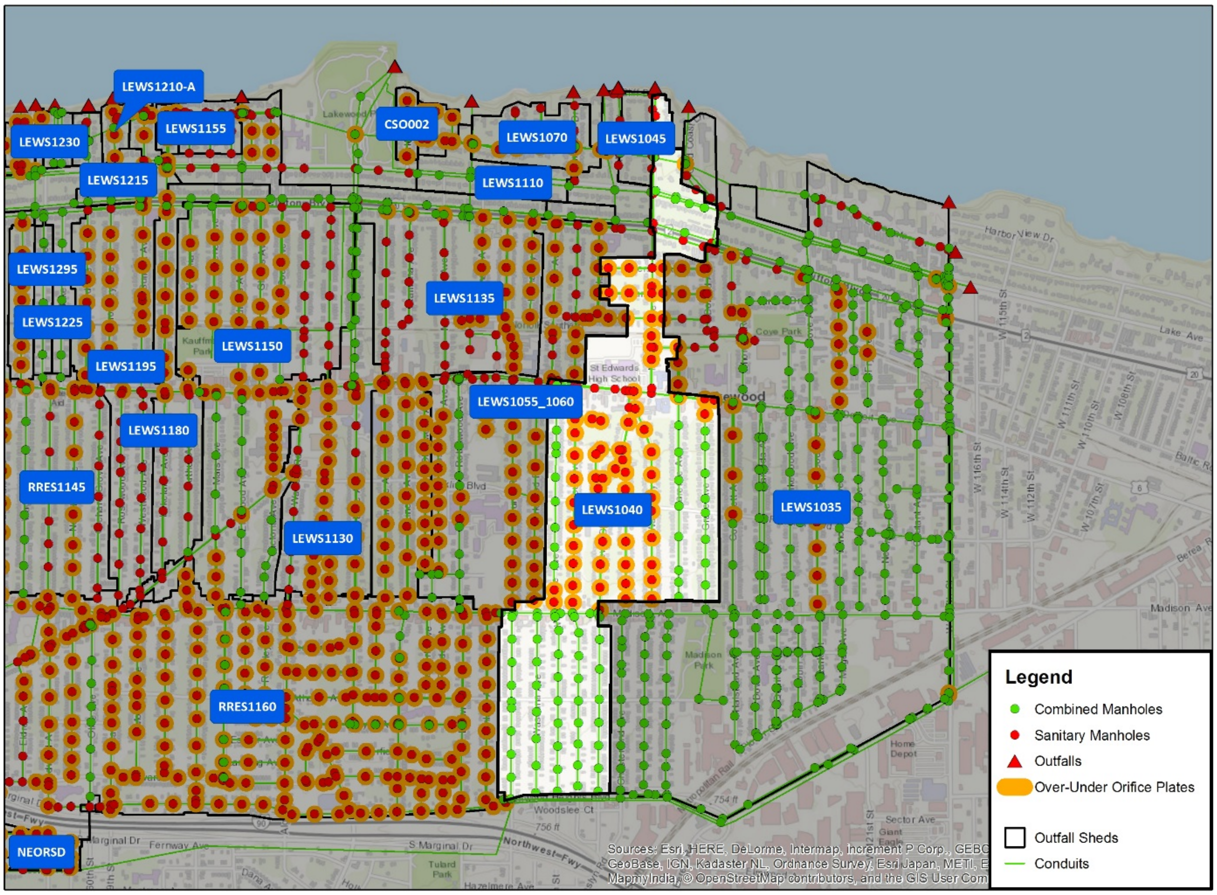


FIGURE 7-12. LEWS 1040 sewershed

7.10.2 Levels of Control Considered

LEWS 1040 is not a permitted CSO, and therefore the following levels of control were evaluated based upon the alternative reviewed as follows:

- Option A – Tunnels with two-year, five-year, and 10-year storm analysis.
- Option B – Source control, green infrastructure, and relief sewers with 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, five-year, and 10-year storm analysis.
- Option C – Relief sewers with 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, and five-year storm analysis.

7.10.3 Alternatives Considered

Option A – The Madison East tunnel/Detroit East tunnels

Madison East/Detroit East tunnels: This tunnel is designed to capture overflows from the Madison Avenue combined sewer at Lewis Avenue and Elbur Avenue to eliminate pollutant loads to the storm sewer on each of those streets and to reduce or eliminate discharge of pollutants at LEWS 1040. The Detroit East tunnel is a 4,140 LF storage/conveyance tunnel from Elbur Avenue to Newman Avenue. The storage tunnel is deep enough to be below all utilities and in suitable strata.

Madison East tunnel: The Madison East tunnel is sized to receive the overflow volumes from the combined sewer on Madison Avenue. The overflows at Lewis and Elbur will be directed to a drop shaft at the intersection of each street, then stored in the tunnel until after the storm event. At the east end of the tunnel, a dewatering pump station will be provided to empty the tunnel into the combined sewer on Madison Avenue at Newman. The dewatering pump station should be sized to dewater the tunnel within 24 hours.

No green infrastructure is included for any of the combined sewers in this area. No improvements were made to any of the combined sewer tributary to these overflows with this alternative solution set.

No relief sewers to mitigate basement flooding were developed in the model for the combined sewers in this area since relief would need to be provided through new storm sewers. This approach was judged not to be feasible.

Pipe sizes within the tunnel vary with level of control are as follows:

- The two-year storm requires a 7-foot diameter pipe.
- The five-year storm requires a 9-foot diameter pipe.
- The 10-year storm requires an 11-foot diameter pipe.

The pipes are common available reinforced concrete pipe sizes. The next largest common pipe size was used to provide the required storage volume.

Detroit East tunnel: This tunnel is designed to capture overflows from the Detroit Avenue sanitary sewer to eliminate pollutant loads to the storm sewer at the overflows along Detroit and to reduce or eliminate discharge of pollutants at LEWS 1040 and LEWS 1055. The Detroit East tunnel is a 3,200 LF storage/conveyance tunnel from Robinwood Avenue to Grace Avenue. The tunnel intercepts all sanitary and combined sewer from the south. To insure the storm sewers have only runoff from the public right of way, manholes need to be separated for all streets within the sewershed. The storage tunnel is deep enough to be below all utilities and in suitable strata but shallow enough to allow the tunnel to drain by gravity to the interceptor at the intersection of

Edgewater Drive and Nicholson Avenue. Relief sewers are provided on side streets intersecting Detroit Avenue.

The intersecting streets where overflow flows are captured are (in west to east order):

- Robinwood (LEWS 1055-D) *
- Wyandotte (LEWS 1040-F) *
- Elbur (LEWS 1040-E)
- Clarence (LEWS 1040-B) *
- Grace (LEWS 1040-C) *

** signifies combined sewer streets with overflows.*

The sanitary sewer overflow on Detroit east of Elbur is also diverted to the tunnel.

The lowest portion of the tunnel has a 12-inch drain line that is always open that drains the tunnel of any flow in the tunnel. The 12-inch line starts at the intersection of Nicholson and Detroit Avenue and runs north on Nicholson where it connects (drops) into the interceptor at Edgewater.

There is no new overflow constructed for the tunnel. Should the tunnel fill up beyond its capacity, the flow from the side streets will overflow to the storm sewer on Detroit at the remaining CSOs located at Robinwood, Wyandotte, Elbur, Detroit East of Elbur, Clarence, and Grace.

There is no private property source control on the over-under sewered streets included with this option nor is any green infrastructure included for streets with combined sewers. Therefore, relief sewers are needed to mitigate potential basement flooding. The relief sewers are located on side streets and are directly connected to the conveyance/storage tunnel. Consequently, there are drop structures at most intersections along Detroit Avenue.

TABLE 7-21. LEWS 1040 Relief sewers included with all tunnel options

ITEM	LENGTH (LF)
Relief sewers: 12-inch diameter	30,077
Relief sewers: 15-inch diameter	254
Relief sewers: 24-inch diameter	9,439
Relief sewers: 36-inch diameter	5,684

Pipe sizes for the tunnels vary with level of control as follows:

- The two-year storm requires a 9-foot diameter pipe.
- The five-year storm requires an 11-foot diameter pipe.
- The 10-year storm requires a 12-foot diameter pipe.

The pipes sizes are common available reinforced concrete pipe sizes. The next largest common pipe size was used to provide the required storage volume.

Option B – Source control/GI/relief sewers

Option B solutions considered public and private property solutions. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Public system rehab in combined sewer areas includes green infrastructure development in the public right of way behind the street curb line.

Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. Private property rehab in combined sewer areas includes storm water source removal from the sanitary lateral and routing to the green infrastructure system in the right of way.

Public solutions also include relief sewers and regulator modifications. Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers.

Five-year

The five-year event with 0 overflow solution set is the same as the previous 0/TY overflows control with a modification to the relief sewers as follows:

TABLE 7-22. LEWS 1040 option B, five-year relief sewers

STREET	DIAMETER	LENGTH (LF)
Nicholson (Detroit to Edgewater)	30"dia	2,514
Nicholson (Detroit to Edgewater)	24"dia	631
Lake (East of Nicholson)	12"dia	205
Clifton (East of Nicholson)	12"dia	1,764
Detroit (Nicholson to Clarence)	12" dia	346
Detroit (Nicholson to Robinwood)	30" dia	1,271
Detroit (Nicholson to Robinwood)	24" dia	584
Detroit (Nicholson to Robinwood)	18" dia	716
Madison (Lewis to 117th)	24" dia	363
Madison (Lewis to 117th)	36" dia	4,240

Modifications were also made to regulators LEWS 1040A, LEWS 1040B, LEWS 1040C, LEWS 1040E, LEWS 1055D, LEWS 1055E and LEWS 1040G.

10-year

The 10-year event with 0 overflow solution set is the same as the five-year event with 0 overflows control with a modification to the relief sewers as follows:

TABLE 7-23. LEWS 1040 option B, 10-year relief sewers

STREET	DIAMETER	LENGTH (LF)
Nicholson (Detroit to Edgewater)	36"dia	2,130
Nicholson (Detroit to Edgewater)	30"dia	1,015
Lake (East of Nicholson)	12"dia	418
Clifton (East of Nicholson)	18"dia	1,320
Clifton (East of Nicholson)	12"dia	445
Detroit (Nicholson to Grace)	18" dia	346
Detroit (Nicholson to Grace)	12" dia	353
Grace	12" dia	200
Detroit (Nicholson to Robinwood)	30" dia	1,514
Detroit (Nicholson to Robinwood)	24" dia	1,057
Waterbury	12" dia	20
Robinwood	18" dia	427
Robinwood	12" dia	988
Cedarwood	12" dia	363
Madison (Lewis to 117th)	24" dia	363
Madison (Lewis to 117th)	48" dia	4,240

Modifications were also made to regulators LEWS 1040E and LEWS 1040G.

Option C – Relief sewers

Option C solutions considered public property solutions. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. No public system rehab is required in combined sewer areas.

Public solutions also comprise of relief sewers and regulator modifications. Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers.

Two-year

The two-year event with 0 overflow solution set is the same as the previous typical year 0 overflows control with a modification to the relief sewers as follows:

TABLE 7-24. LEWS 1040 option C, two-year relief sewers

STREET	DIAMETER	LENGTH (LF)
Nicholson (Detroit to Edgewater)	36"dia	1643
Nicholson (Detroit to Edgewater)	30"dia	1491
Lake (East of Nicholson)	12"dia	205
Clifton (East of Nicholson)	18"dia	1764
Detroit (Nicholson to Grace)	24" dia	346
Detroit (Nicholson to Grace)	18" dia	353
Clarence	18"dia	40
Clarence	12"dia	400
Detroit (Nicholson to Robinwood)	36" dia	1270
Detroit (Nicholson to Robinwood)	30" dia	1300
Waterbury	12"dia	529
Lewis	12"dia	920
Robinwood	18"dia	988
Robinwood	12"dia	415
Madison (Lewis to 117th)	36" dia	363
Madison (Lewis to 117th)	48" dia	4240

Modifications were made to regulator LEWS 1040A and LEWS 1040E.

Five-year

The five-year event with 0 overflow solution set is the same as the previous two-year 0 overflows control with a modification to the relief sewers as follows:

TABLE 7-25. LEWS 1040 option C five-year relief sewers

STREET	DIAMETER	LENGTH (LF)
Nicholson (Detroit to Edgewater)	48"dia	1,540
Nicholson (Detroit to Edgewater)	36"dia	487
Nicholson (Detroit to Edgewater)	30"dia	1,107
Lake (East of Nicholson)	24"dia	210
Lake (East of Nicholson)	12"dia	205
Clifton (East of Nicholson)	18"dia	2,119
Detroit (Nicholson to Grace)	24" dia	346
Detroit (Nicholson to Grace)	18" dia	353
Clarence	18"dia	40
Clarence	12"dia	400
Grace	18”dia	200
Detroit (Nicholson to Robinwood)	36" dia	1,514
Detroit (Nicholson to Robinwood)	30" dia	1,056
Waterbury	12"dia	1,019
Lewis	12"dia	920
Elbur (Madison to Detroit)	12"dia	416
Wyandotte (Madison to Detroit)	24"dia	925
Wyandotte (Madison to Detroit)	12"dia	320
Robinwood	24"dia	989
Robinwood	18"dia	415
Robinwood	12"dia	754
Cedarwood	12"dia	363
Madison (Lewis to 117th)	48" dia	5,379
Madison (Lewis to 117th)	60" dia	364

Wyandotte (South of Madison)	30"dia	921
Wyandotte (South of Madison)	18"dia	307
Elbur (South of Madison)	18"dia	1,198
Elbur (South of Madison)	12"dia	279
Bunts (South of Madison)	18"dia	621

All previous modifications made at regulators were also performed in this level of control analysis.

7.10.4 Construction Cost Analysis

TABLE 7-26. LEWS 1040 solution set options and construction costs in million $

	A	B	C
2-Year	$87.3		$25.4
	-Direct B/C/E/F to Detroit East Tunnel. Direct G/H to Madison East Tunnel.		-Relief to Interceptor picking up all CSOs and manage at 059.
5-Year	$106.9	$41.5	$31.3
	-Direct B/C/E/F to Detroit East Tunnel. Direct G/H to Madison East Tunnel.	-Source Control, Green Infrastructure, Relief	-Relief to Interceptor picking up all CSOs and manage at 059.
10-Year	$122.0	$43.1	
	-Direct B/C/E/F to Detroit East Tunnel. Direct G/H to Madison East Tunnel.	-Source Control, Green Infrastructure, Relief	

7.11 LEWS 1055-1060

LEWS1055_1060 Outfall Shed

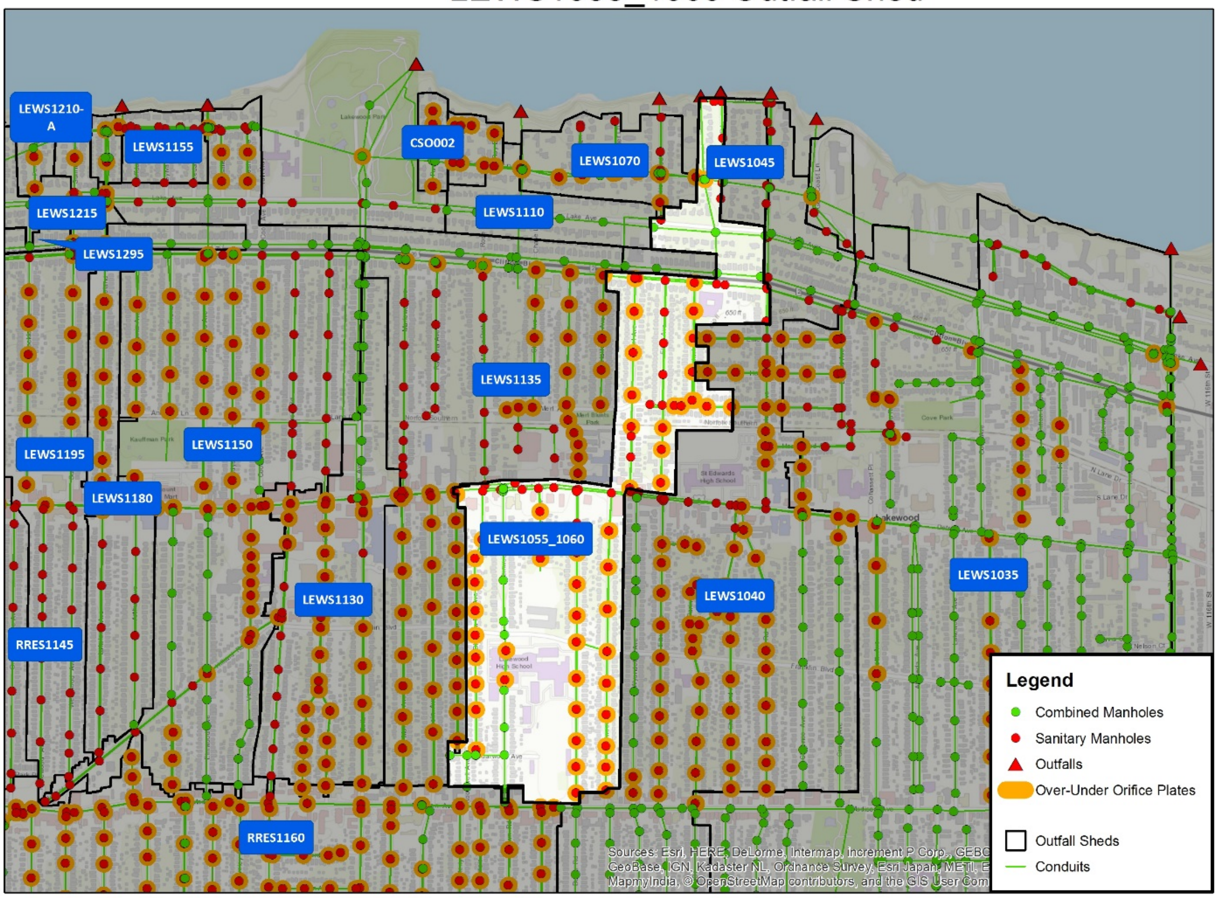


FIGURE 7-13. LEWS 1055-1060 sewershed

7.11.2 Levels of Control Considered

LEWS 1055-1060 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.11.3 Alternatives Considered

Option A – Source control, green infrastructure, relief sewer, regulator modifications

Two-year

The two-year solution set includes full public and private source control, relief sewers, a pump station, and regulator modifications. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers.

Full source control would be completed on the following streets; Blossom Park, Parkhaven, Bunts, Parkwood, Giel, Elbur, Jackson, and Lake Road. Included in the construction would be lining of approximately 14,269 LF of under sewer, 46 manhole separations, and public/private source control for approximately 447 parcels.

Green infrastructure would be built on the following streets; Roosevelt and Robinwood, serving sewersheds of approximately 20 acres.

Regulator modifications included weir raising to one foot from the invert of the manhole at LEWS 1055-E, bulkhead of LEwES1055-A and a new relief connecting LEWS 1055-C to relief storage

TABLE 7-27. LEWS 1055-1060 two-year relief sewers

STREET	DIAMETER	LENGTH (LF)
Detroit	60” relief	1,008
Giel to Whippoorwill	24” relief	165
Whippoorwill	72” relief	368

Two minor pump stations and force mains were include to dewater the relief/storage pipes noted above.

Five-year
The five-year solution set includes the same improvements as the two-year level of control. Additionally, a 12-inch relief sewer approximately 330 LF was needed along Giel.

10-year
The 10-year solution set includes the same improvements as the five-year level of control. Additionally, a 12-inch relief sewer approximately 294 LF was needed along Elbur.

Option B – Detroit East storage tunnel
Please refer to LEWS 1040 for details related to the Detroit East storage tunnel and its analysis components.

7.11.4 Construction Cost Analysis

TABLE 7-28. LEWS 1055-1060 solution set options and construction costs in million $

	A	B
2-Year	$17.49	Incl w/LEWS 1040
	-Source Control, Green Infrastructure, Relief Sewer, Regulator Modification	-Detroit Ave East Tunnel
5-Year	$17.76	Incl w/LEWS 1040
	-Source Control, Green Infrastructure, Relief Sewer, Regulator Modification	-Detroit Ave East Tunnel
10-Year	$17.89	Incl w/LEWS 1040
	-Source Control, Green Infrastructure, Relief Sewer, Regulator Modification	-Detroit Ave East Tunnel

7.12 LEWS 1180

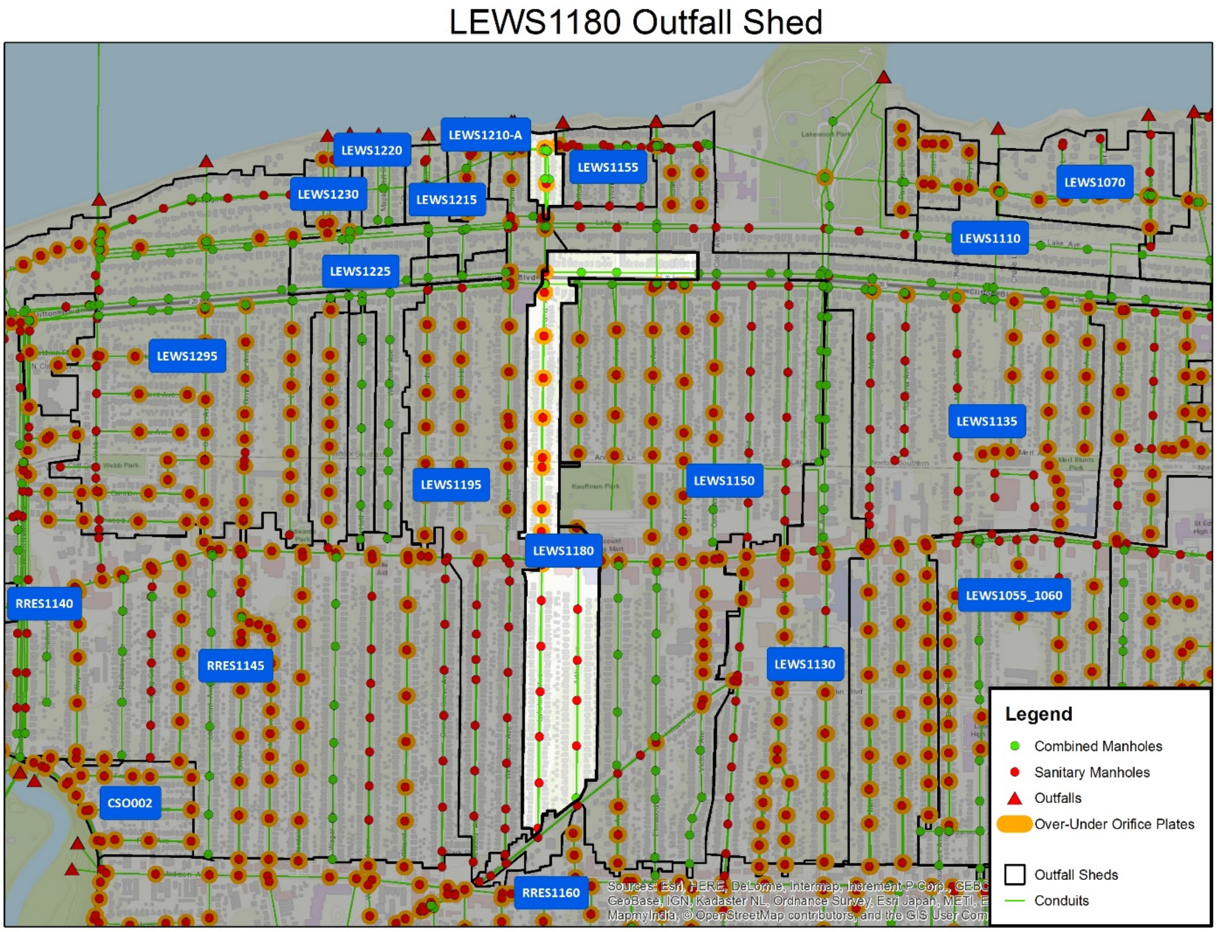


FIGURE 7-14. LEWS 1180 sewershed

7.12.2 Levels of Control Considered

LEWS 1180 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.12.3 Alternatives Considered

Option A – Source control, relief sewers, storm sewers

Two-year

The two-year solution set includes full public and private source control, relief sewers, and storm sewers. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower.

The source control was modeled on Arthur, Lakeland, Westwood, Rosewood, Orchard Grove, Andrews, French, Virginia, Summit, Detroit, and Clifton including a total of approximately 962 properties. Some of these streets have over-under sewers contributing to and influencing neighboring sheds. Approximately 37 manhole separations would be performed in this sewershed.

Approximately 2160 LF of relief sewer along Lakeland, and 630 LF of new storm sewer along Clifton would be necessary.

Five-year, and 10-year
The solution sets for the five-year and 10-year storms are the same, but costs increase slightly due to increased relief/storm sewer sizes.

7.12.4 Construction Cost Analysis

TABLE 7-29. LEWS 1180 solution set options and construction costs in million $

	A
2-Year	$19.64
	-Source control, relief sewer, storm sewer
5-Year	$19.71
	-Source control, relief sewer, storm sewer
10-Year	$19.84
	-Source control, relief sewer, storm sewer

7.13 LEWS 1195

LEWS1195 Outfall Shed

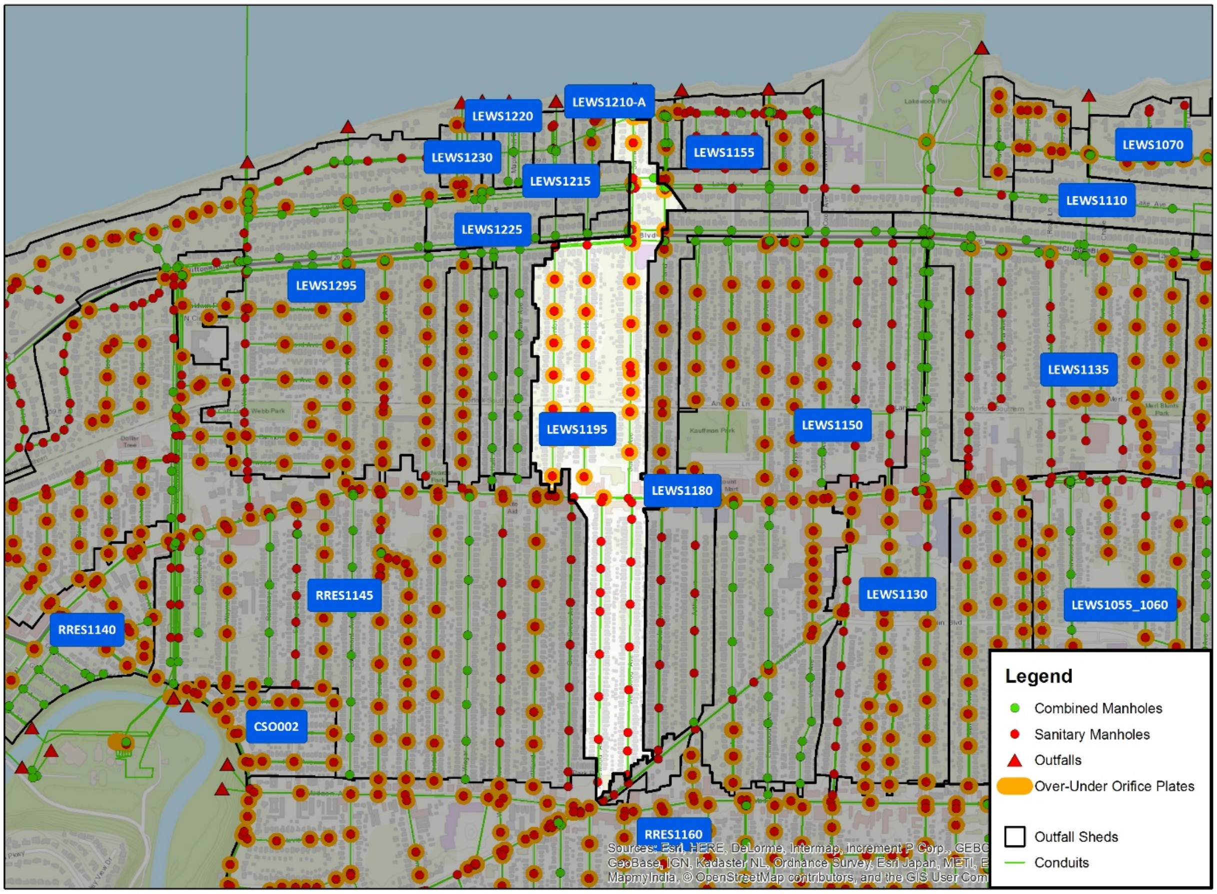


FIGURE 7-15. LEWS 1195 sewershed

7.13.2 Levels of Control Considered

LEWS 1195 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.13.3 Alternatives Considered

Option A – Bulkhead

Two-year, five-year, 10-year

The LEWS 1195 outfall receives flow from an interceptor relief combined sewer overflow. The characteristics of this outfall are similar to those of CSO 059. The sewer system contributes flows directly to the interceptor, however, there is an interceptor relief contributory to the LEWS 1195 outfall pipe.

The only alternative considered was to bulkhead or close this overflow. The result is treating flows resulting from high HGLs in the interceptor at other locations, such as the plant or the CSO 059 (LEWS 1035) interceptor relief overflow.

7.13.4 Construction Cost Analysis

TABLE 7-30. LEWS 1195 solution set options and construction costs in million $

	A
2-Year	$0.61
	Close off and convey more to Interceptor and manage at 059 (consider impacts to Edgewater hydraulics)
5-Year	$0.61
	Close off and convey more to Interceptor and manage at 059 (consider impacts to Edgewater hydraulics)
10-Year	$0.61
	Close off and convey more to Interceptor and manage at 059 (consider impacts to Edgewater hydraulics)

7.14 LEWS 1210

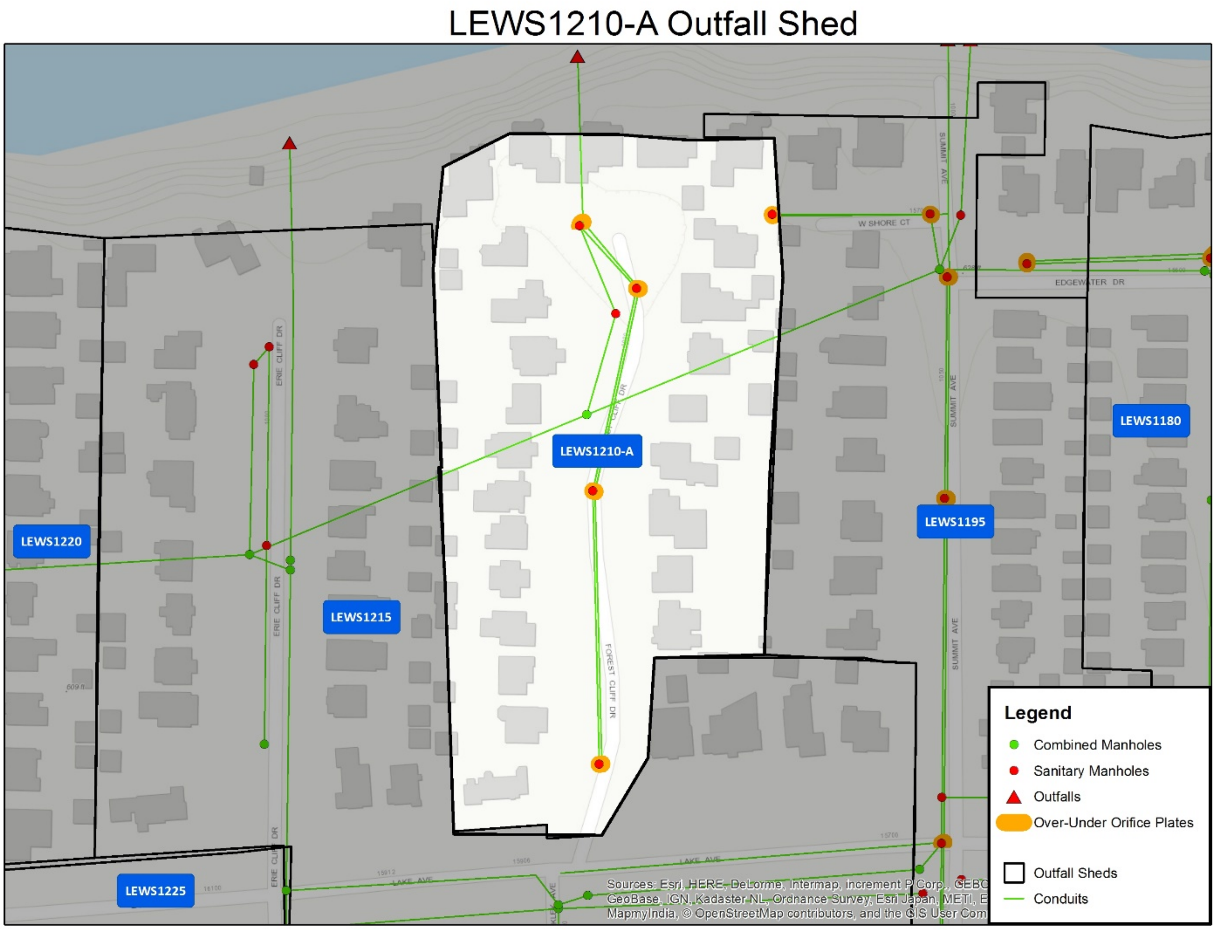


FIGURE 7-16. LEWS 1210 sewershed

7.14.2 Levels of Control Considered

LEWS 1210 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.14.3 Alternatives Considered

Option A – Source control

Two-year, five-year, and 10-year

The two-year, five-year, and 10-year solution sets include public system rehab and private property rehab. Public system rehab in over-under sewer areas includes manhole separation, sanitary sewer lining, lateral lining to the right of way, and replacement of existing P-traps on all streets receiving public system rehab. Private property rehab in over-under areas includes storm water source removal from the sanitary lateral and routing to the storm sewer system. A total of 4 manholes would be separated and 847 LF of sewer would be lined. Private laterals would be replaced on approximately 24 properties along Forest Cliff Drive.

7.14.4 Construction Cost Analysis

TABLE 7-31. LEWS 1210 solution set options and construction costs in million $

	A
2-Year	$0.6
	Source control
5-Year	$0.6
	Source control
10-Year	$0.6
	Source control

As a unique smaller sewershed, the existing system captures more pollutants than the proposed improvements would. This is because the existing system has a large amount of capacity, and currently stormwater flows to the treatment plant for treatment. Under proposed conditions, total CBOD discharged to the receiving waters would increase due to increased stormwater discharge through the outfall pipe. This should be considered a low priority outfall.

7.15 LEWS 1215

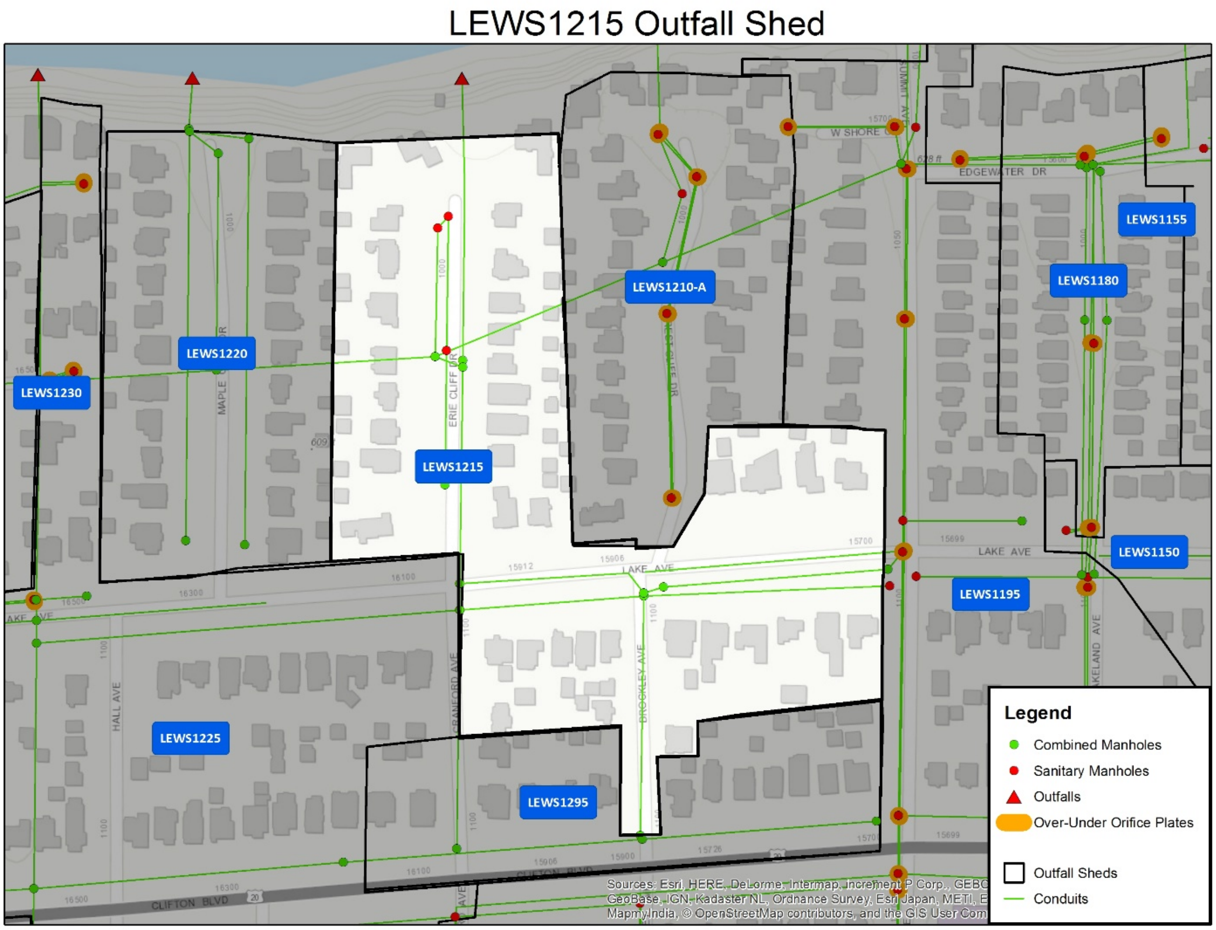


FIGURE 7-17. LEWS 1215 sewershed

7.15.2 Levels of Control Considered

LEWS 1215 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.15.3 Alternatives Considered

Option A – Control technologies vary with level of control

Two-year and five-year

The two-year and five-year solution sets include a 24-inch relief sewer. Relief sewers are parallel sewers to the existing sanitary or combined sewer to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower.

The 24-inch relief sewer would be constructed on Lake Avenue between Erie Cliff Drive and Summit Avenue (743 LF).

10-year
The 10-year solution set includes the 24-inch relief sewer and regulator modifications. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers. For LEWS 1215, the overflow weir would be raised by six inches.

Option B – Regulator modifications

Two-year, five-year, and 10-year
The two-year, five-year and 10-year solution set includes regulator modifications. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers. For LEWS 1215, the overflow weir would be raised by six inches.

Option C – Storm sewer

Two-year, five-year, and 10-year
The two-year, five-year and 10-year solution set includes a new storm sewer rerouting catch basins along Lake Avenue to a new 24-inch storm sewer extending from Cranford and Lake Avenue approximately 745 LF east discharging at the Summit Avenue Over sewer.

7.15.4 Construction Cost Analysis

TABLE 7-32. LEWS 1215 solution set options and construction costs in million $

	A	B	C
2-Year	$0.4	$0.1	$0.4
	Combined Relief Sewer/ Reg Mods	Regulator Modification	New Storm Sewer
5-Year	$0.4	$0.1	$0.4
	Combined Relief Sewer/ Reg Mods	Regulator Modification	New Storm Sewer
10-Year	$0.4	$0.1	$0.4
	Combined Relief Sewer/ Reg Mods	Regulator Modification	New Storm Sewer

The relief sewer alternatives (Option A) and storm sewer options (Option C) are less cost-effective than the regulator modification alternatives (Option B). The10-year Option B solution set provides the greatest LOS benefit for the investment. Option C is currently being considered, as of the time of this report, for inclusion with the on-going 2019 Watermain Replacement and Other Miscellaneous Improvements Project. An added benefit of option C is removing additional clearwater from the interceptor, whereas the other two alternatives increase conveyance of combined sewage to the interceptor. The storm sewer option does deactivate the LEWS 1215A CSO weir during the two-year, five-year, and 10-year storms, with only storm flow discharging from the LEWS 1215 outfall.

7.16 LEWS 1220

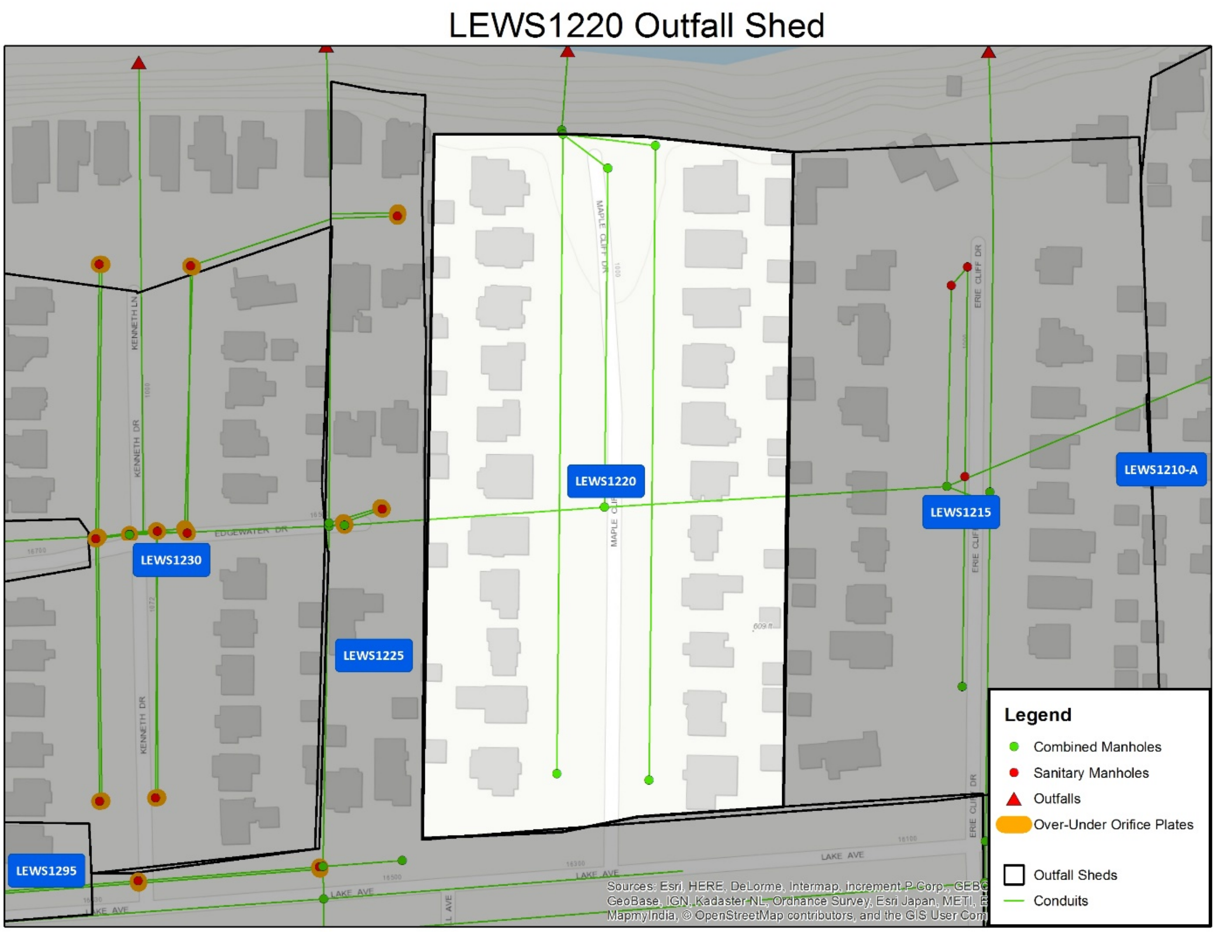


FIGURE 7-18. LEWS 1220 sewershed

7.16.2 Levels of Control Considered

LEWS 1220 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.16.3 ALTERNATIVES CONSIDERED

Option A – Control technologies vary with level of control

Two-year

The two-year solution set system rehab consists of green infrastructure in combined sewer areas, with placement in the right of way behind the street curb line. Individual property sewer rehab in combined sewer areas includes storm water source removal from the sanitary lateral and routing to the green infrastructure system in the right of way. Sewer rehab would be performed on Maple Cliff Drive.

Five-year

The five-year solution set includes public system rehab, private property rehab and regulator modifications. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers. The public and private rehab recommendation follows the two-year solution set. The regulator modifications include increasing the weir elevation from 1.12 feet to 1.5 feet.

10-year

The 10-year solution set includes public system rehab, private property rehab and regulator modifications. The public and private rehab recommendation follows the two-year and five-year solution sets. The regulator modifications include increasing the weir elevation from 1.12 feet to 2.0 feet.

7.16.4 CONSTRUCTION COST ANALYSIS

TABLE 7-33. LEWS 1220 solution set options and construction costs in million $

	A
0/Typical Year	$0.3
	Source control and GI
2-Year	$0.3
	Source control and GI
5-Year	$0.3
	Source control and GI
10-Year	$0.3
	Source control and GI

The majority of the cost for these solution sets is included with the public and private rehabilitation recommendations which are the same for each LOS, and therefore it would be cost-effective to select the 10-year solution set and provide a higher LOS for this area. This is a privately owned street, which has been recently repaved.

7.17 LEWS 1225 (CSO 055)

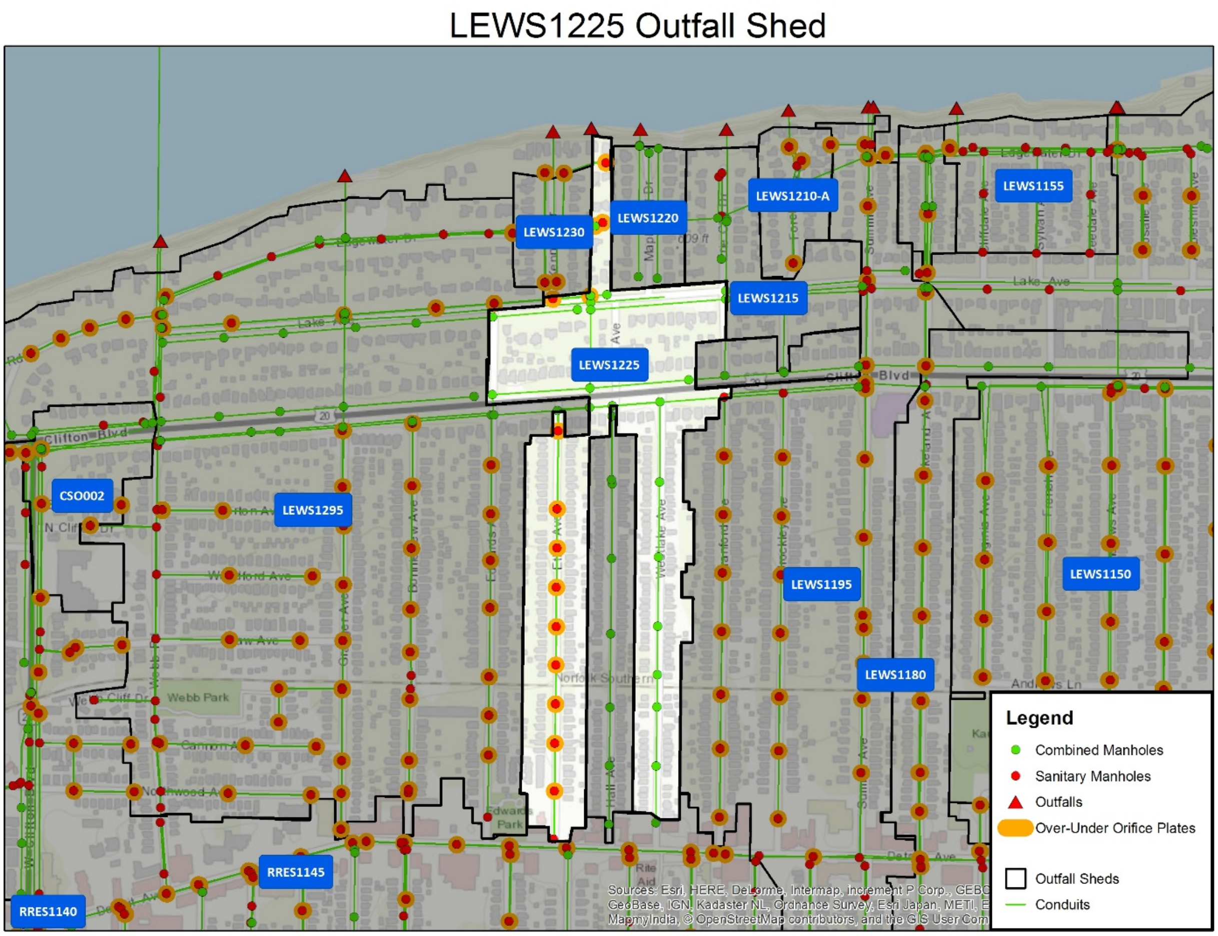


FIGURE 7-19. LEWS 1225 sewershed

7.17.2 Levels of Control Considered

LEWS 1225 is a permitted CSO (CSO 055) therefore the following levels of control were initially evaluated; 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year storm analysis.

7.17.3 Alternative Considered

Option A – Sewer separation with source control

4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year

With a 30-inch combined sewer coming into the CSO structure and an 8-inch outlet to the interceptor, source control and green infrastructure were screened out as not capable of reducing wet-weather flows sufficiently to reduce CSOs to 4 or less in the typical year of rainfall. Sewer separation with source control were selected as the most viable control technologies. Given the extent of the proposed improvements, this sewershed does not have scalable technologies.

The separation solution set includes new sanitary sewers, source control on public and private property and regulator modification. The following new sanitary sewers will be required:

TABLE 7-34. LEWS 1225 new sanitary sewers

STREET	EXTENT	DIAMETER	LENGTH (LF)
Westlake	Detroit to Clifton	8"dia	2,171
Clifton south side	Westlake to Hall	8"dia	400
Clifton north side	Westlake to Hall	8"dia	1,252
Hall	Clifton to Lake	8"dia	396
Lake Road	Hall to Maple Cliff	8"dia	645
Maple Cliff	Lake Rd to Interceptor	8"dia	443

- Source control on public property includes the new sewer and lateral connections to the right of way with test tees within the treelawn. Also included in public property source control is a test tee on the existing lateral and removal of a running trap or P-trap if existing.
- Private property source control includes extending the lateral to the house and using the existing lateral for footer drains, downspouts, area drains and any other stormwater drains.
- The existing combined sewer will become a converted storm sewer.
- The combined sewer manhole section on the north side of Clifton Blvd from Hall to Edwards will be partially bulkheaded to prevent backup into this converted storm sewer.
- CSO 055 will carry stormwater only after these modifications are made. As such, the sewer will be modified to eliminate the weir and bulkhead the 8-inch pipe which formerly went to the interceptor.

This solution set has zero overflows for all the control levels: 4/TY, 3/TY, 2/TY, 1/TY, 0/TY, two-year, five-year, and 10-year storm analysis.

7.17.4 Construction Cost Analysis

TABLE 7-35. LEWS 1225 solution set options and construction costs in million $

	A
4/Typical Year	$4.4
	Sewer Separation
3/Typical Year	$4.4
	Sewer Separation
2/Typical Year	$4.4
	Sewer Separation
1/Typical Year	$4.4
	Sewer Separation
0/Typical Year	$4.4
	Sewer Separation
2-Year	$4.4
	Sewer Separation
5-Year	$4.4
	Sewer Separation
10-Year	$4.4
	Sewer Separation

The number of CSOs is reduced to zero.

7.18 LEWS 1285-1295

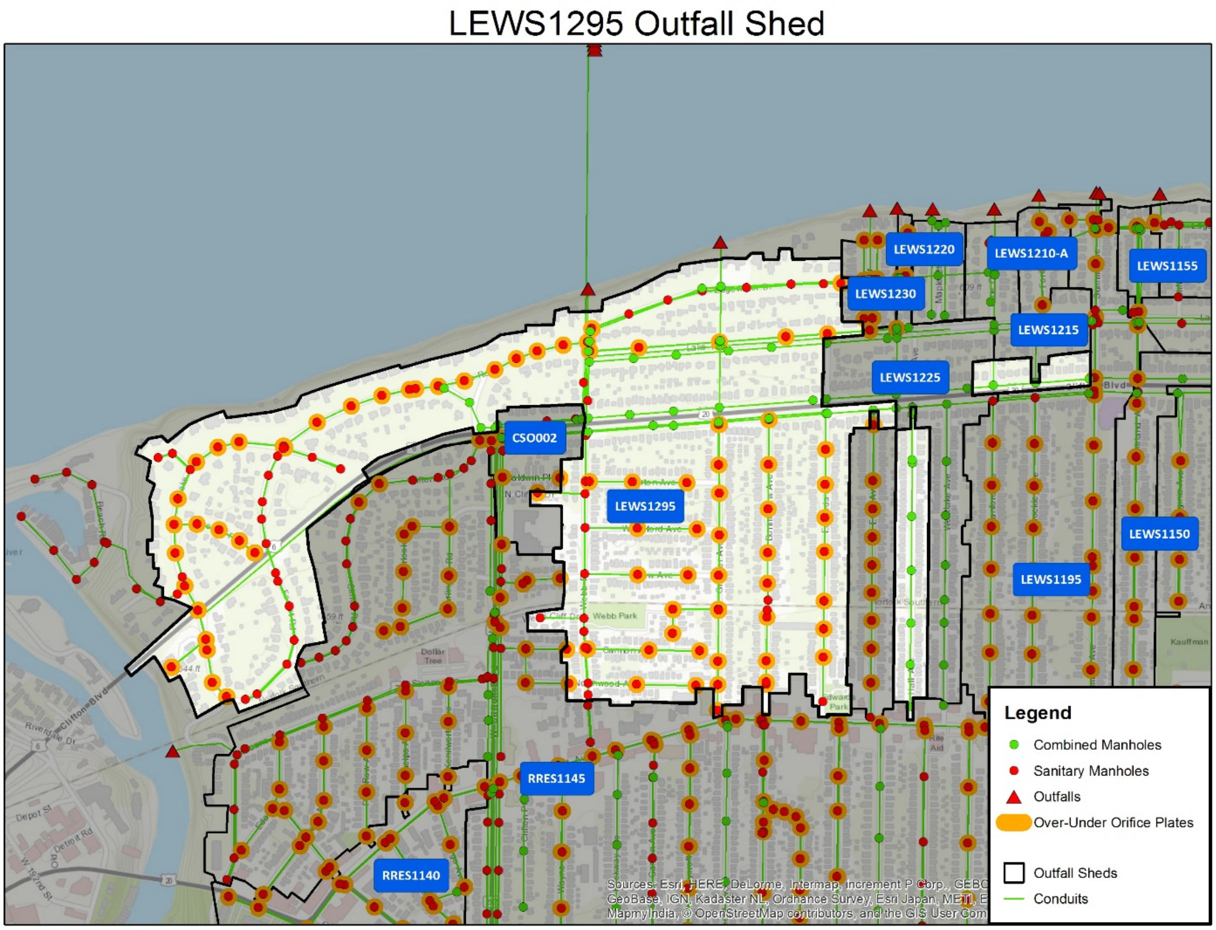


FIGURE 7-20. LEWS 1295 sewershed

7.18.2 Levels of Control Considered

LEWS 1285-1295 is not a permitted CSO, and therefore the following levels of control were evaluated; two-year, five-year, and 10-year storm analysis.

7.18.3 Alternatives Considered

Seven manhole separations are needed along the north side of Lake Avenue from Webb to the east. At the easternmost manhole, a bulkhead is needed between the combined sewer and the over-under system along the north side of Lake Avenue between Kenneth and Maple Cliff. These improvements are planned to be completed in 2019 as a part of the city's Lake Avenue water main replacement and miscellaneous improvements project.

Option A –Technologies vary with level of control

Two-year

The two-year solution set includes regulator modifications and relief sewers. Regulator modifications include change of overflow control restrictions and/or elevation with possible changes in size to sanitary connector pipes to downstream sanitary sewers. Relief sewers include parallel sewers to the existing sanitary or combined sewers to provide flow capacity at a hydraulic grade line to prevent basement surcharging where deep enough or below existing conditions operation where shallower. Some public sewer rehab work (seven manhole separations) is also needed along Lake Avenue, and are happening as a part of the Lake Avenue Water Main Replacement and Miscellaneous Improvements Project.

The existing 12-inch storm sewers under the center portion of the roadway which connect to the combined sewer running from Granger to the North, will be disconnected from the combined line (24 inches) and reconnected to the "over" sewer in the north tree lawn. This removes stormwater from the combined system in attempts to de-activate LEWS 1295-A. These improvements are also happening as a part of the Lake Avenue Water Main Replacement and Miscellaneous Improvements Project.

Separately, the relief connection between the storm sewer and combined sewer on Clifton Boulevard, just north of Granger Avenue, would be bulkheaded. This improvement is happening as a part of the Lake Avenue Water Main Replacement and Miscellaneous Improvements Project.

For LEWS 1295-B, along the south side of Lake Avenue, a relief sewer is needed from the combined sewer connection at Webb and Lake Avenue for approximately 1,776 LF ranging from 24-inch to 15-inch in diameter.

The existing relief connection between the 10-inch combined sewer traveling north at the intersection of Lake Avenue and Webb Road to the parallel 18-inch storm sewer would be bulkheaded. The existing combined sewer would be redirected to the new relief sewer. The relief sewer will run parallel to the 10-inch combined sewer on the south side of Lake Avenue starting at Edwards Avenue and running west to Webb Road. The flow will discharge into the Interceptor running south on Webb Road.

Five-year, 10-year

The five-year and 10-year solution sets include the same modifications as the two-year, with slightly increased relief sewer sizes.

An additional relief sewer is also necessary (approximately 930 LF of 12-inch diameter sewer) along the north side of the street from the interceptor east to the combined line extending north of Granger.

7.18.4 Construction Cost Analysis

TABLE 7-36. LEWS 1285-1295 solution set options and construction costs in million $

	A	B
2-Year	$1.43	n/a
	Relief Sewer, Regulator Modification	Relief sewer, Regulator Modification, Storm Sewer
5-Year	$1.88	n/a
	Relief Sewer, Regulator Modification	n/a
10-Year	$1.96	n/a
	Relief Sewer, Regulator Modification	n/a

Minimizing high local HGLs is the driver for the projects under the levels of control simulated.

7.19 Composite Solution Sets

Composite (citywide) solution sets were developed for the following levels of control:

- 4 per typical year for permitted CSOs and control of a two-year storm for other outfalls
- 0 per typical year for permitted CSOs and control of a two-year storm for other outfalls
- Two-year storm level of control for both permitted CSOs and other outfalls
- Two-year storm level of control for permitted CSOs and control of five-year storm for other outfalls

Composite solutions were run for the full typical year. Pollutant tracers were used in the model to report CBOD by sewage at each outfall.

These costs are preliminary and planning level in nature, and will continue to be refined through the project planning and design process. Costing methods are included in Chapter 8.

CHAPTER 8 – COSTING METHODOLOGY AND ANALYSIS

Lakewood's Integrated Wet Weather Improvement Plan Phase 2 is founded upon the principle of achieving the best, most cost-effective improvement for the expenditure of Lakewood's limited financial resources. This cost-effectiveness consideration was recognized in the city's NPDES permit language concerning this plan and is fundamental under EPA's Integrated Planning Framework and the National CSO Policy. This chapter outlines the approach by which costs were estimated for each alternative and cost-effectiveness was evaluated for each considered level of control. The chapter concludes with a prioritized list of projects to be implemented as the IWWIP program.

8.1 Cost Methodology

Planning level costs associated with defined alternatives involved estimating the cost to develop projects, involving capital, and to operate and maintain these solutions for a sustained period of time. Developing costs in this fashion allowed for comparison of projects from a capital and long term life cycle cost basis. All capital costs estimated were assumed to be in 2019 dollars.

Capital costs for each alternative solution were developed in a parametric fashion; whereby, individual components of the solution, such as length of a specific diameter pipe, were estimated and a unit cost assigned. After total capital construction costs were determined, additional costs were applied to represent costs allied to project development including engineering/construction related services, administration, and legal costs. After factoring in these allied costs, an additional contingency cost was assigned that was deemed appropriate for this level of planning information. While the city has not yet made a decision on how private source control will be paid for, the IWWIP Phase 2 costs were developed to represent the full cost this solution would require, regardless of the funding source.

Operations and maintenance (O&M) costs were also tailored to the type of project under consideration, as shown in Table 8-1. Treatment-oriented project O&M costs were estimated using standard cost curves for the type of process involved.

Sources for the construction and maintenance costs included: known local construction costs from similar projects in or near Lakewood, communication with other consulting firms and municipalities to understand maintenance costs, and literature research.

For green infrastructure the following literature sources were reviewed: City of Lancaster, Pa. (www.saveitlancaster.com/), Minnesota Stormwater Manual (www.stormwater.pca.state.mn.us), Costs of Stormwater Management Practices in Maryland Counties (University of Maryland), Low Impact Development at the Local Level by ECONorthwest for Clackamas County, Oregon.

TABLE 8-1. Construction and maintenance costs

ITEM	$/UNIT	MAINTENANCE COST AND FREQUENCY
Below Ground Storage*	$4-$18/gallon	$0.04 per gallon of storage capacity per year
Above Ground Storage	$2.50/gallon (includes contingencies)	$0.04 per gallon of storage capacity per year
Bulkhead a pipe	$3,000 each	-
Sealing invert plates	$1,000 each	-
Weir raise	$3,000 each	-
Green Infrastructure	$60,600/acre	$750/acre/per year
CIPP Lining	$7/in-ft diameter	-
Public right of way source control	$4,000/property	-
Private property source control	$8,000/property	-
Manhole Separation	$57,000	-
New sewer	See table 2	$3/ft every 6 years
Pump station (2MGD or less)**	$250,000-$500,000 depending on flow rate	5% of construction cost for maintenance every year 33% of construction cost to replace pump and electrical every 20 years

**Below ground storage costs were refined during composite modeling based upon site-specific constraints and considerations.*
***Larger pump stations such as at 052 and 059 were included in storage facility costs.*

Lakewood's source control pilot study was an important reference for many costs, namely $8,000 per home for work on private property and $4,000 per home for work within the right of way. Each manhole separation costs $57,000 and cost to re-line sewers was assumed to be $7 per inch diameter foot, based on Lakewood's pilot study experience and other recent and local projects. Source control requires no new maintenance for the city, since there are no new pipes for the city to maintain, for this reason, no maintenance costs were applied when estimating source control costs. For the purposes of this planning level analysis, the private property maintenance costs of piping associated with storm drainage is considered to be negligible.

CT Consultants developed planning-level cost estimates for each tunnel option. These costs were included in the Chapter 7 discussion, where appropriate. An independent estimator, McGuiness Unlimited, Inc., separately estimated and arrived at similar tunnel costs, thereby validating the values used.

New sewer pipe construction costs are detailed in Table 8-2. Costs for new sewers are based on recent experience in Lakewood and the surrounding region. Lakewood's Department of Public Works past experience shows that it costs $3 per foot when cleaning sewers.

TABLE 8-2. New sewer construction costs

INCH DIAMETER	$/LINEAR FOOT
84	$ 1,650.00
78	$ 1,500.00
72	$ 1,370.00
66	$ 1,280.00
60	$ 1,180.00
54	$ 1,040.00
48	$ 910.00
42	$ 810.00
36	$ 760.00
30	$ 650.00
27	$ 570.00
24	$ 520.00
21	$ 480.00
18	$ 450.00
15	$ 420.00
8-12	$ 400.00

All construction costs listed above do not include the 15 percent construction contingency. Thirty percent was added on top of construction contingency to account for all project costs, such as: design, construction observation, legal, permits, and administration. The project costs listed elsewhere in this IWWIP include the 15 percent and 30 percent additions. All costs are in 2019 US dollars. All costs are planning-level, AACE level 4.

For life cycle costs, the plan initially considered several periods of operation. With capital costs associated to project development occurring at year zero, recurring annual costs were added over a period of years: 10 years, 20 years, and 100 years. Life cycle costs were estimated by multiplying the yearly maintenance costs by 10, 20, and 100 years, and adding in the initial capital costs. Pumps were assumed to be replaced every 20 years. Ultimately, the life cycle costs were not a factor in project selection as the most significant differentiator was project cost.

8.2 Cost-Effectiveness Analysis

The term “cost-effectiveness” is intended, as per the NPDES permit language, to mean a measure of cost divided by the reduction objective measures, such as discharge frequency, volume, and pollutant loadings. The cost aspect of this analysis can represent either capital or life-cycle costs. As stated in Chapter 6 and 7, the development of alternatives occurred in two steps, first with developing alternative solutions on an outfall-specific basis, and next with system-wide solutions.

The outcome of this analysis will be largely influenced by the flow conditions that are managed by individual projects sized to achieve a specific level of control. The best perspective is provided by a summary of typical year model discharges. As an example, Figure 8-1 shows the amount of flow volume discharging from CSO 052 in the identified typical year events from the sewer model. At this outfall, 75 percent of the annual volume is accounted for by the fifth-largest event and smaller events. As the level of control options for this outfall start with four discharges per typical year, the minimum control achieved by any project is 75 percent. Any incrementally higher level of control will likely be less cost-effective when viewed in terms of additional cost for additional volume capture.

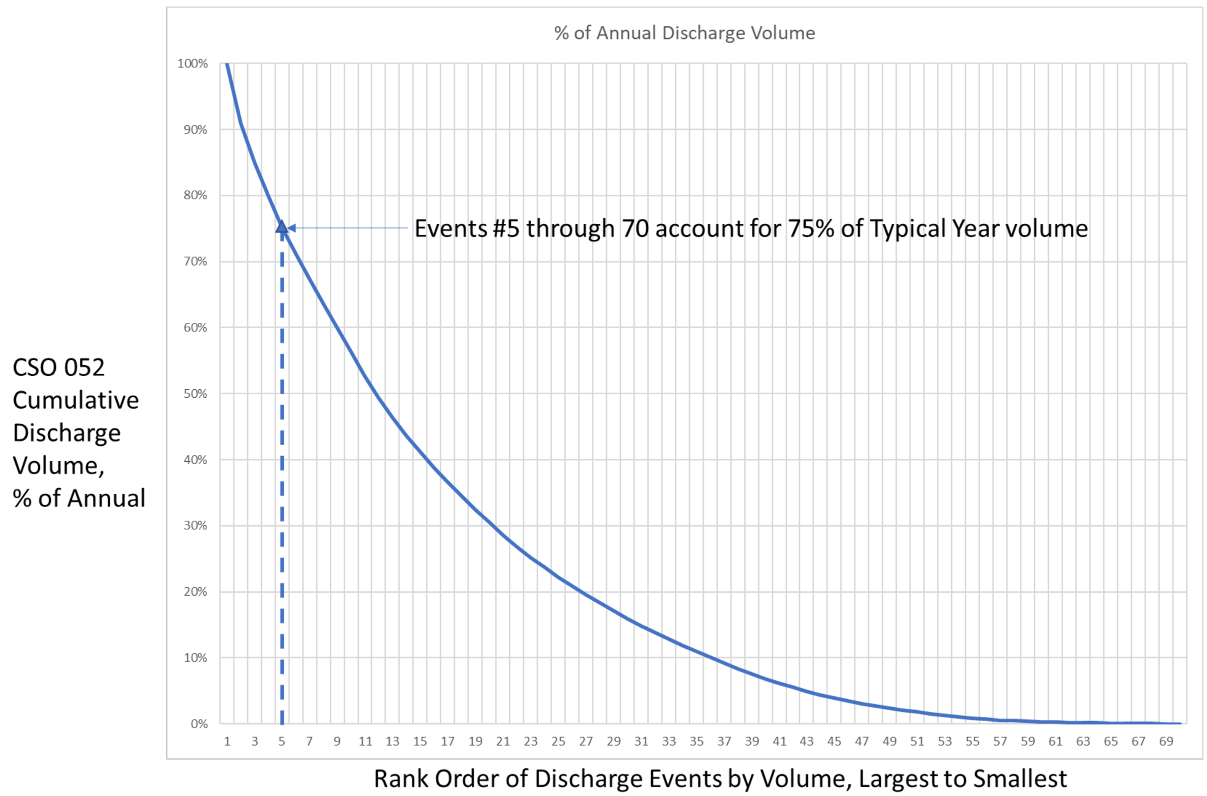


FIGURE 8-1. CSO 052 typical year discharge volume by event

Pursuing the example further, the total volume discharged in a typical year from CSO 052 is 159 MG. By comparison, the discharge in a two-year, two-hour storm event is 12 MG, the five-year is 16 MG, and the 10-year is 18 MG. If a 6 MG storage facility is used to achieve 4 per typical year control at this site, it has the potential to capture 50 percent of the two-year, 38 percent of the five-year, and 33 percent of the 10-year storm event volumes as well. All of this is accomplished with the cost to achieve the 4 per typical year control, that actually would capture 90 percent of the annual discharge volume at this site.

The CSO 052 discharge control solutions include storage for the 4 per typical year and 3 per typical year objectives, and the capital cost for these projects is $22 and $23 million, respectively.

The additional typical year volume capture achieved by going to 3 per typical year is 1.44 MG, making the unit cost for this additional storage $0.69 per gallon captured, compared to the $0.15 per gallon that the storage for 4 per typical year accomplished. When viewed in terms of pollutant capture, two comparisons are useful: total CBOD and Sewage CBOD. Table 8-3 summarizes the cost-effectiveness comparison for these two levels of control.

TABLE 8-3. CSO 052 cost-effectiveness comparison of four to three per typical year control

PARAMETER	FOUR PER TYPICAL YEAR	THREE PER TYPICAL YEAR	INCREMENTAL DIFFERENCE
Storage Volume, MG	6.1	6.4	0.3
Estimated Capital Cost, $ million	22	23	$1.0
Typical Year Volume Controlled, MG	146	147.2	1.2
Typical Year CBOD Controlled, pounds	9,787	9,845	58
Typical Year Sewage CBOD Controlled, pounds	4,048	4,062	14
Typical Year TSS Controlled, pounds	19,569	19,693	124
Typical Year E coli Controlled, quadrillion CFU	5,221	5,243	22
Volume unit cost to control, $/gallon	$0.15	$0.16	$0.83
CBOD unit cost to control, $/pound	$2,248	$2,235	$17,241
Sewage CBOD unit cost to control, $/pound	$5,435	$5,416	$71,429
TSS unit cost to control, $/pound	$1,124	$1,117	$8,065
E coli unit cost to control, $/quadrillion CFU	$4,214	$4,196	$45,455

8.2.2 COST-EFFECTIVENESS ANALYSIS OF OUTFALL-SPECIFIC SOLUTIONS

The cost-effectiveness analysis on an outfall-specific basis is mostly appropriate for any of the permitted CSO outfalls, of which there are six addressed by this IWWIP. The other three permitted CSOs have already been addressed by other city projects, as described in previous chapters of this IWWIP (CSO 002, CSO 053, and CSO 054). Additionally, three CSOs (055, 056A&B, 057, and 058) have virtually no cost differences between typical year levels of control and make them poor candidates for cost-effectiveness evaluation. The following discussion summarizes the cost-effectiveness evaluation for the two remaining permitted CSOs that could be evaluated with this methodology: CSOs 052 and 059, respectively.

CSO 052 (RRES 1160-1165)

CSO 052 was evaluated for a range of 4 to 0 untreated discharges per typical year. Based on the alternatives evaluation described in Chapter 7, the selected projects for achieving each level of control were as follows:

- **Four per typical year**: 6.1 MG elevated storage at WWTP and aerial sewer across river
- **Three per typical year**: 6.4 MG elevated storage at WWTP and aerial sewer across river
- **Two per typical year**: Public system rehabilitation and relief sewers needed to prevent system surcharge
- **One per typical year**: Public system rehabilitation and relief sewers needed to prevent system surcharge

- **Zero per typical year**: Public system rehabilitation and relief sewers needed to prevent system surcharge

Table 8-43 summarizes the modeled outcomes of each project in terms of volume control and pollutant control. Figure 8-23 provides a graphical depiction of these results for volume, CBOD, and *E. coli* control. This analysis shows a dramatic reduction in CBOD and *E. coli* from current to 4 per typical year, and then an increase in unit cost to control at the 3 per typical year which is most dramatic in CBOD and *E. coli* terms. The control technology change to public system rehab to achieve 2 through 0 per typical year has an important impact on this analysis in that this approach does not control stormwater pollution discharged at CSO 052, which is controlled by the storage solution at lower levels of control. It should be noted that there is very little difference between the public system rehabilitation solution at the 2, 1, and 0 per typical year outcome, as the solution is effectively sized to achieve 0 per typical year. As a result, the incremental unit costs actually go negative from 3 per typical year to 2 per typical year in each category. Either storage solution controls 70 percent more CBOD than any of the prohibitively expensive, higher levels of control that rely on public system rehabilitation.

A two-year design storm solution was also evaluated for CSO 052, which would require separating the public system and performing private source control. This level of effort was deemed necessary as the results of the Clean Water Pilot Project (located within the CSO 052 tributary area) are not yet available and will not be until later in 2019. The estimated cost of this solution was over $72 million, or roughly $50 million more than the storage tank solution that would provide 4 per typical year performance. As this storage tank would capture stormwater pollution that would discharge without treatment under the non-storage options, controlling to 4 per typical year level achieves a greater pollution control level than a solution that achieves two-year design storm control.

CSO 059 (LEWS 1035, LEWS 1040, LEWS 1070, and LEWS 1195)

CSO 059 was evaluated for a range of 4 to 0 untreated discharges per typical year. As described in Chapter 7, the CSO 059 solution is required to manage overflows from the interceptor at outfall LEWS 1035 as a result of more flow sent to the interceptor to prevent sewage discharges at LEWS 1040, LEWS 1070, and LEWS 1195. Sites were looked at individually during the site by site analysis, and therefore the effects of projects in other areas were not yet factored in to the analysis at the point which the sizes below were developed. The CSO 059 storage sizes were refined further once the composite models were developed. Based on the alternatives evaluation described in Chapter 7, the selected projects for achieving each level of control were as follows:

- **Four per typical year**: Relief to interceptor and tank storage at 059 of 0.004 MG.
- **Three per typical year**: Relief to interceptor and tank storage at 059 of 0.198 MG.
- **Two per typical year**: Relief to interceptor and tank storage at 059 of 0.426 MG.
- **One per typical year**: Relief to interceptor and tank storage at 059 of 0.739 MG.
- **Zero per typical year**: Relief to interceptor and tank storage at 059 of 1.440 MG.

Table 8-4 summarizes the modeled outcomes of each project in terms of volume control and pollutant control. Figure 8-2 provides a graphical depiction of these results for volume, CBOD, and

E. coli control. This analysis shows significantly more cost-effective pollution reduction when achieving 3 or 4 per typical year control across all categories.

TABLE 8-4. Cost-effectiveness summary for CSO 052

Control Objective	Project Cost ($ M)	CSO Cost Benefit			CBOD Cost Benefit			*E. coli* Cost Benefit		
		Typical Year CSO Controlled (MG)	Total $ / CSO Controlled (Gal)	Incremental $ / Gal CSO Controlled*	Typical Year CBOD Controlled (lb)	Total $ / CBOD Controlled (lb)	Incremental. $ / lb CSO Controlled*	Typical Year *E. coli* Controlled (Quadrillion CFU)	Total $ / *E. coli* Controlled (Quadrillion CFU)	Incremental $ / Quadrillion CFU *E. coli* Controlled*
None	$0.00	0.00	$0.00	$0.00	0.00	$0.00	$0.00	0.00	$0.00	$0.00
4/TY	$22.00	31.19	$0.67	$0.71	2,492	$8,830	$8,830	1.03E+09	$0.02	$0.02
3/TY	$23.00	32.59	$0.67	$0.71	2,549	$9,024	$17,544	1.04E+09	$0.02	$0.06
2/TY	$62.63	5.01	$12.51	-$1.44	1,467	$42,692	-$36,644	9.20E+08	$0.07	-$0.33
1/TY	$63.48	5.01	$12.68	$1,223	1,467	$43,267	$4,805,912	9.20E+08	$0.07	$30.48
0/TY	$65.73	5.01	$13.13	Not applicable	1,467	$44,800.75	Not applicable	9.20E+08	$0.07	Not applicable

*Incremental unit cost derived by dividing the cost difference between two control objectives by the residual load difference between those same two control objectives.

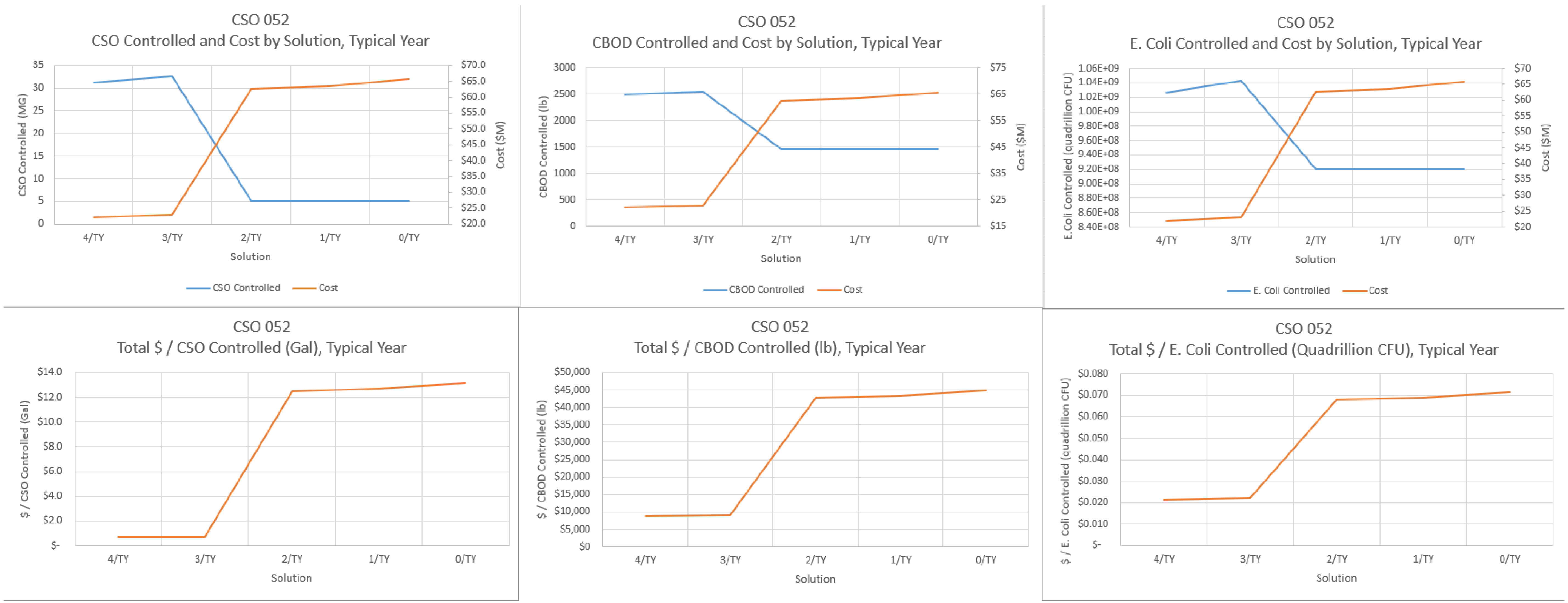


FIGURE 8-2. Cost-effectiveness charts for CSO 052

TABLE 8-5. Cost-effectiveness summary for CSO 059

Control Objective	Cost ($ M)	CSO Control Cost Benefit			CBOD Control Cost Benefit			*E. coli* Control Cost Benefit		
		Typical Year CSO Controlled (MG)	Total $ / CSO Controlled (Gal)	Incremental $ / Gal CSO Controlled*	Typical Year CBOD Controlled (lb)	Total $ / CBOD Controlled (lb)	Incremental. $ / lb CSO Controlled*	Typical Year *E. coli* Controlled (Quadrillion CFU)	Total $ / *E. coli* Controlled (Quadrillion CFU)	Incremental $ / Quadrillion CFU *E. coli* Controlled*
None	$0	0.00	$0.00	$0.00	0.00	$0.00	$0.00	0.00	$0.00	$0.00
4/TY	$28.58	22.23	$1.29	$1.29	2033	$14,056	$14,056	1.43E+09	$0.02	$0.02
3/TY	$29.35	22.81	$1.29	$1.33	2112	$13,895	$9,747	1.51E+09	$0.02	$0.01
2/TY	$29.87	23.89	$1.25	$0.48	2127	$14,041	$34,554	1.48E+09	$0.02	-$0.02
1/TY	$31.41	24.72	$1.27	$1.85	2170	$14,475	$36,129	1.51E+09	$0.02	$0.06
0/TY	$34.51	41.18	$0.84	$0.19	2381	$14,490	$14,649	1.51E+09	$0.02	#DIV/0!

*Incremental unit cost derived by dividing the cost difference between two control objectives by the residual load difference between those same two control objectives.

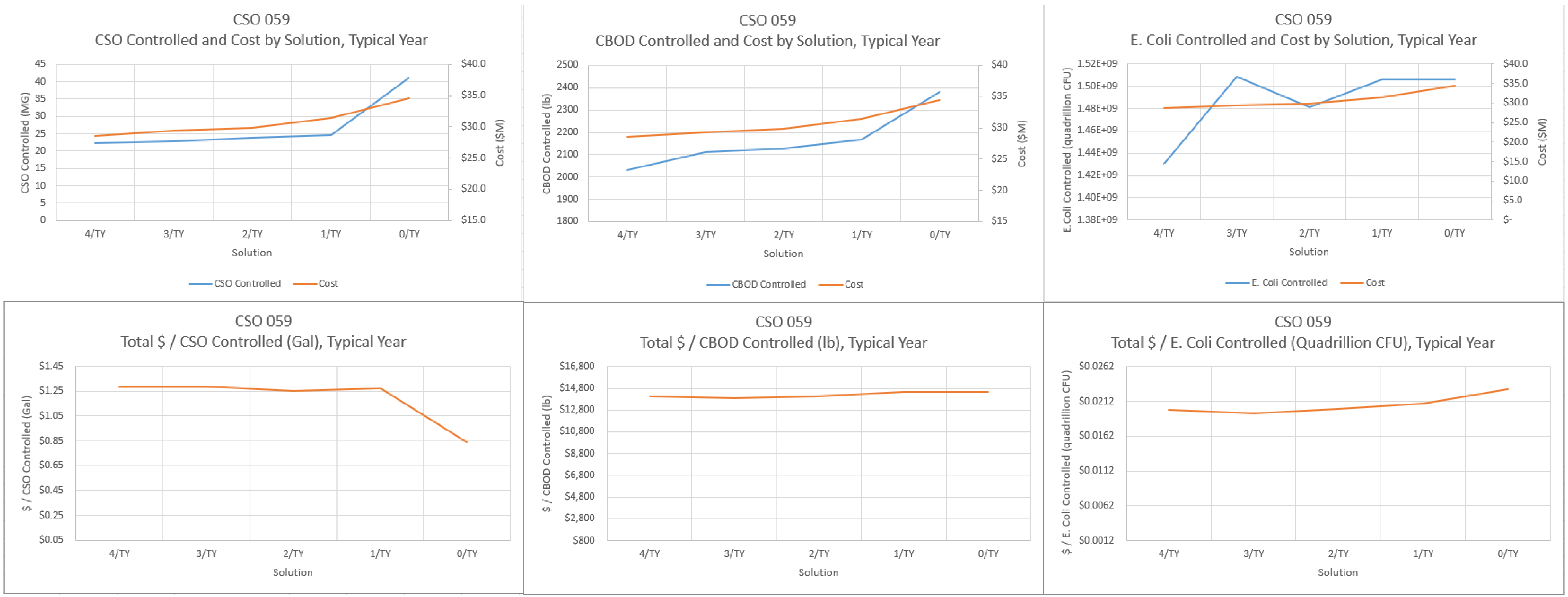


FIGURE 8-3. Cost-effectiveness charts for CSO 059

8.2.3 Analysis of Systemwide Solution Sets

With the completion of site by site analysis, sets of projects were assembled so that systemwide solutions could be considered using a "composite model" of the system with all improvements incorporated. This was an especially important step in the planning process for the alternatives being considered at overflow sheds which interact with each other, and for alternatives based upon flow conditions in the interceptor. Table 8-6 defines the specific solutions that would be included to achieve a specified level of control for a given outfall. Table 8-7 presents the typical year modeling results for the considered systemwide level of control alternative solution sets. Figure 8-25 is a graphical depiction of those results.

While prior modeling results presented the effectiveness of outfall-specific projects in terms of reducing overall volume and pollution discharge to the Rocky River and Lake Erie, the systemwide solution set analysis was expanded to consider the effectiveness in reducing discharged Sewage CBOD, which is believed to be the most reliable indicator of pollution reduction that can be achieved by these projects. Figure 8-26 presents a comparison of Sewage CBOD control achieved currently, after the HRT facility is online, and after each progressive systemwide overflow control solution set is implemented. This comparison shows a clear improvement from the post-HRT scenario to the 4 per Typical Year plus two-year scenario. Beyond this level of control, there is very little additional capture available to be gained as a result of the infrequency of discharges and the limited sewage pollution associated with these discharges.

The 4 per Typical Year plus two-year scenario also provides the additional benefits of higher total CBOD, TSS, and *E. coli* capture than the higher levels of control as result of controlling all discharges at CSO 052. With the storage solution at this location, all discharges up to the established level of control are eventually sent through full treatment and disinfection. Higher levels of control cost more and do not capture and treat the stormwater pollution discharged at this site. In particular, the 0 per Typical Year plus two-year requires approximately $60 million more in capital funding but results in higher levels of total CBOD, TSS, and *E. coli*, although Sewage CBOD discharge is less. This incremental improvement in Sewage CBOD has a unit cost to control that is 70 times the unit cost for controlling the increment from the Existing plus HRT to the 4 Year plus two-year scenario. Because of the inherent removal efficiencies in the two treatment plants, no control alternatives can achieve higher than 97.5 percent Sewage CBOD control.

The transition from individual outfall analysis to systemwide composite analysis required all points of sewage discharge be reconciled and omitted. Additional infrastructure necessary in certain sewersheds would increase the total project costs compared to the site-by-site analyses. However, because of the overlap and interaction between neighboring sheds, and because of the impact of certain projects on the resulting flows in the interceptor, efficiencies were also recognized during this step. These changes have been documented separately. As with all models and planning level analysis, on-going flow monitoring, sampling, reporting, flood reports, and community feedback will be crucial to the successful future implementation of the proposed projects.

TABLE 8-6. Summary of Solutions Associated with Level of Control Options for Each Outfall

Outfall Name	CSO	Preferred Solution			
		4/TY	0/TY	2-Y	5-Y
LEWS 1040		N/A	N/A	Relief to interceptor picking up all CSOs and manage at 059, public system rehabilitation, regulator modifications	Relief to interceptor picking up all CSOs and manage at 059, public system rehabilitation, weir modification
RRES 1160-1165	052	Above ground storage at WWTP	Public system rehabilitation, relief sewers,	Public system rehabilita-tion, relief sewers, and private source control	N/A
LEWS 1035	059	Underground tank storage (storage to man-age also LEWS 1040 and LEWS 1195 TBD)	Underground tank storage (storage to manage also LEWS 1040 and LEWS 1195 TBD)	Underground tank stor-age (Using Costs for 0/TY as larger than two-year)	N/A
LEWS 1195		N/A	N/A	Close relief overflow, new pump station to interceptor to manage at 059, public system rehabilitation	Close relief overflow, new pump station to interceptor and man-age at 059, public sys-tem rehabilitation
LEWS 1070		N/A	N/A	Pump to interceptor, public system rehabilita-tion, storm sewers	Pump to interceptor, source control on pri-vate property, public system rehabilitation, storm & relief sewers
RRES 1145		N/A	N/A	Source control on pri-vate property, public system rehabilitation, relief sewers, , regulator modifications, green infrastructure	Source control on pri-vate property, public system rehabilitation, sewer separation, reg-ulator modifications, green infrastructure
LEWS 1180		N/A	N/A	Source control on pri-vate property, public system rehabilitation, relief sewer, storm sew-er	Source control on pri-vate property, public system rehabilitation, relief sewer, storm sewer
LEWS 1150-1155	056A&B	See 0 per typical year (not scala-ble)	Source control, green infra-structure, relief sewers, regula-tor modifica-tions, pump station	Source control on pri-vate property, public system rehabilitation, green infrastructure, relief sewers, regulator modifications, pump station	N/A

Outfall Name	CSO	Preferred Solution			
		4/TY	0/TY	2-Y	5-Y
LEWS 1130-1135	057	Belle storage tunnel	Belle storage tunnel, Lake-wood Park storage basin	Belle storage tunnel, Lakewood Park storage basin	N/A
LEWS 1225	055	N/A	Sewer separa-tion, source control on pri-vate property, public system rehabilitation, regulator modi-fication	Sewer separation, source control on pri-vate property, public system rehabilitation, regulator modification	Sewer separation, source control on pri-vate property, public system rehabilitation, regulator modification
LEWS 1110	058	Raise weir	Raise weir, in-crease inter-ceptor con-nector pipe size	Raise weir, increase in-terceptor connector pipe size	N/A
LEWS 1045		N/A	N/A	Add pump station to serve area, regulator modifications, sanitary sewer, relief sewer	Add pump station to serve area, regulator modifications, sanitary sewer, relief sewer
LEWS 1055-1060		N/A	N/A	Source control on pri-vate property, public system rehabilitation, relief sewer, regulator modification, sanitary sewer	Source control on pri-vate property, public system rehabilitation, relief sewer, regulator modification, sanitary sewer
LEWS 1285-1295		N/A	N/A	Relief sewer, regulator modification, public sys-tem rehabilitation, new sewer	Relief sewer, regulator modification, public system rehabilitation, new sewers
LEWS 1210		N/A	N/A	Source control on pri-vate property, public system rehabilitation	Source control on pri-vate property, public system rehabilitation
LEWS 1215		N/A	N/A	reconstruct connection to interceptor	reconstruct connec-tion to interceptor
LEWS 1220		N/A	N/A	Green infrastructure, regulator modification	Green infrastructure, regulator modification

TABLE 8-7. Comparison of Cost and Effectiveness of Increasing Levels of Control, Typical Year Basis

SCENARIO	IWWIP CAPITAL COST, $ MILLION	IWWIP + HRT CAPITAL COST, $ MILLION	UNTREATED RESIDUAL VOLUME (MG)	UNTREATED RESIDUAL TSS TOTAL (LB)	UNTREATED RESIDUAL CBOD TOTAL (LB)	UNTREATED RESIDUAL CBOD BY SEWAGE (LB)	UNTREATED RESIDUAL E. COLI TCU	% SEWAGE CBOD CAPTURE SYSTEMWIDE	INCREMENTAL $/SEWAGE CBOD LOAD REDUCED, $/LB *
Existing	$0	$0	535.2	57,219	29,805	16,177	1.95E+16	93.71%	$0
Existing Conditions + HRT	$0	$25	529.8	51,870	26,831	14,219	1.65E+16	94.16%	$12,770
4/Typical Year & 2-Year	$156	$181	423.1	14,189	5,481	475	1.13E+15	97.39%	$11,351
0/Typical Year & 2-Year	$231	$256	671.6	40,962	16,782	-	2.51E+15	97.50%	$157,731
2 Year for All Sites	$252	$277	669.0	41,044	16,769	-	2.54E+15	97.50%	Not applicable
2 Year & 5 Year	$259	$284	663.4	40,934	16,726	-	2.53E+15	97.50%	Not applicable

*Incremental unit cost derived by dividing the cost difference between two scenarios by the residual load difference.

FIGURE 8-4. Comparison of Level of Control Options for Lakewood IWWIP

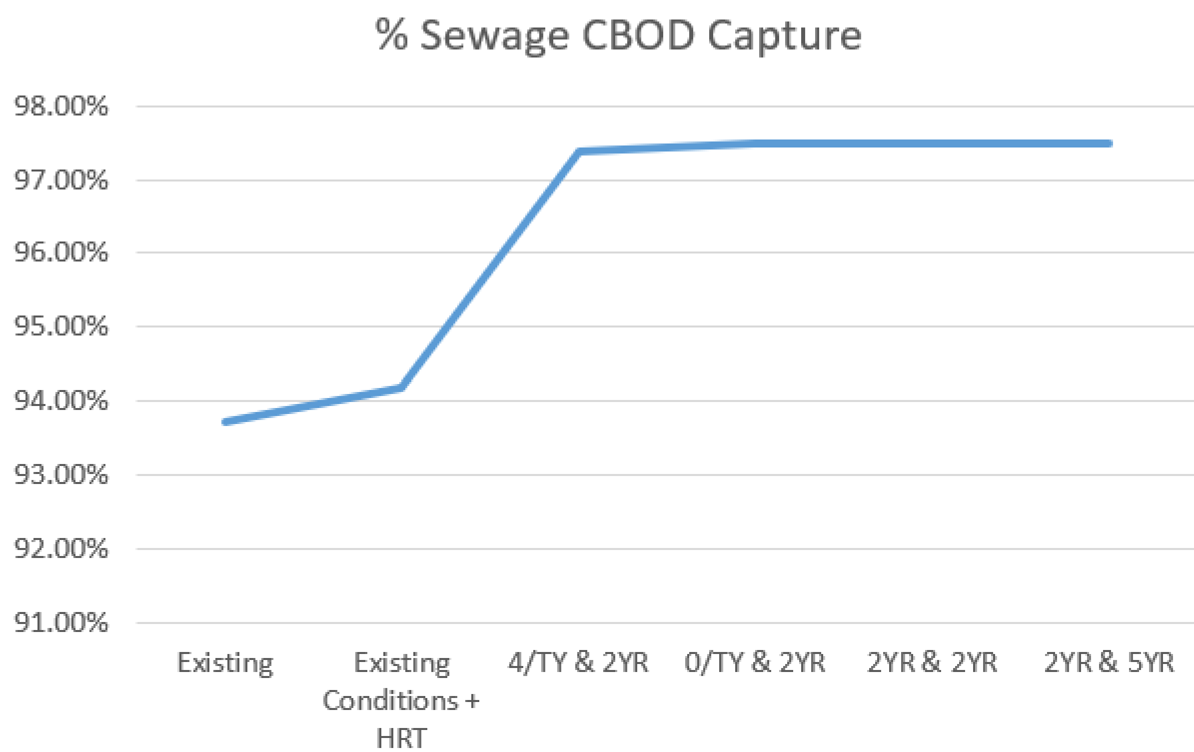


FIGURE 8-5. Sewage CBOD Capture from Existing Through Level of Control Options, Typical Year Basis

8.2.4 Analysis of Systemwide Separation

As a point of comparison, systemwide sewer separation was considered. This concept would include separation on all combined streets, providing either a new sanitary or new storm sewer and correctly connecting private laterals to the separate public sewer lines. This concept was found to be much less cost-effective and providing negligible additional water quality benefit compared to the other systemwide solutions investigated (Table 8-7).

The city recently completed sewer separation on its own accord along Edgewater Drive. The project consisted of a new sanitary sewer in the public right of way and private lateral connections between the new public sanitary sewer and the private property connection points at the right of way, as well as removal and replacement of roadway, sidewalk, and landscaping. The new sanitary sewer line intercepted and separated storm and sanitary flows of approximately 100 properties that previously flowed to a combined sewer. Costs from the project were estimated to be $1.3 million for a stretch of 1,400 LF of sewer. These total project costs ended up breaking down to approximately $770/LF of public sewer installed. Cost data from the clean water source control pilot study revealed private property costs of approximately $8,000 per property to re-plumb the private property storm drainage system and line the sanitary lateral. Approximately 4,460 parcels are connected to combined sewers, and 183,200 LF of combined sewer exist within the system. Likewise, there are approximately 10,091 properties in over-under sewered areas along approximately 345,100 LF of sewer. Due to complexities associated with the placement and connect-ability on streets with little potential for increased sewer depths due to the elevation of downstream trunk sewers, a higher unit cost of $1,000/LF was used in over-under areas.

TABLE 8-8. Systemwide Separation Cost Analysis

ITEM	QUANTITY	UNIT COST	UNITS	COST
Combined Sewers				
Properties	4,640	$ 8,000	$/property	$ 37,120,000
Length of Sewer	183,200	$ 770	$/LF	$ 141,064,000
Over-Under Sewers				
Properties	10,091	$ 8,000	$/property	$ 80,728,000
Length of Sewer	345,100	$ 1,000	$/LF	$ 345,100,000
Total				$ 604,012,000

8.3 Prioritized IWWIP Phase 2 Plan Solutions

The IWWIP priority is based on the analyses presented in this document, which includes achieving a minimum level of control for permitted CSOs at no more than 4 untreated discharges per typical year and to control non-permitted overflows to prevent sewage discharges in a two-year, two-hour design storm event. The Chapter 3 Financial Capability section states that the city would be able to support capital funding for the IWWIP in the amount of $5 million per year starting in 2022. There would be additional capital funds available to support components of this plan that were constituted rehabilitation and repair (R&R) of the public sewer system. In theory, absent any real world limitations on affordability that will control program pace, with R&R funds available, this IWWIP could be completed by 2047.

Project prioritization is primarily based on the cost-effectiveness of the project, in terms of cost per pound of pollution reduced, but also reflective of the appropriate order for construction. Costs for the prioritized list of projects, exclusive of the HRT project already bid for construction, organized by outfall, from this IWWIP are as follows in 2019 construction costs:

1. CSO 052: Construct aerial sewer to WWTP property and 6.1 million gallon above ground storage tank and drainage of stored flows to WWTP for treatment. $23 million.
2. LEWS 1070: Perform source control on public and private system, construct diversion sewer and pump station to convey flows to the interceptor, and construct local storm sewer. $3.1 million.
3. CSO 059: Construct underground storage tank to capture interceptor overflows. $12.2 million.
4. LEWS 1195: Close off connection to outfall. $1.2 million.
5. LEWS 1040: Construct relief sewers to prevent discharges in a two-year design storm and convey flow to interceptor. $25.6 million.
6. CSO 057: Construct tunnel under Belle Ave and storage tank in Lakewood Park. $5.3 million.

7. RRES 1145: Construct Regulator Modifications and perform source control, sewer separation, and green infrastructure improvements throughout tributary area. $31.5 million.
8. CSO 056A&B: Construct Regulator Modifications and perform source control, sewer separation, and green infrastructure improvements throughout tributary area. $18.7 million.
9. LEWS 1180: Construct relief sewer and storm sewer and perform source control throughout tributary area. $19.3 million.
10. LEWS 1225: Perform sewer separation. $4.4 million.
11. LEWS 1110: Construct diversion sewer. $0.1 million.
12. LEWS 1045: Bulkhead interceptor connection and add pump station to serve area. $1.5 million.
13. LEWS 1055-1060: Construct relief sewer and regulator modifications and perform source control and green infrastructure installations throughout tributary area. $5.0 million.
14. LEWS 1285-1295: Construct relief sewer and regulator modifications. $5.1 million.
15. LEWS 1210: Perform source control throughout tributary area. $0.7 million.
16. LEWS 1215: Construct regulator modification. $0.1 million.
17. LEWS 1220: Perform source control throughout tributary area. $0.3 million.

Design of project priority 1, CSO 052 storage, is expected to begin in 2020.

The city outlines these projects in prioritized five-year bundles that would be incorporated as permit-required projects with successive NPDES permit renewals. As such, only five years of project capital would be committed at a time, but each permit term would also include city investments in additional data collection, project evaluation, an IWWIP update, and design for the next permit bundle of projects.

As shown in Figure 8-5, the recommended program would achieve significant reductions in Sewage CBOD with the first $64 million in capital, which would coincide with priorities 1 through 5. Beyond this point in the program, each additional project priority will address a diminishing amount of annual pollution discharge. Using Adaptive Management and the flexibility of Lakewood's IWWIP, those projects will have to be assessed against other measures, such as increased collection system work, that may provide greater environmental benefit for the dollars.

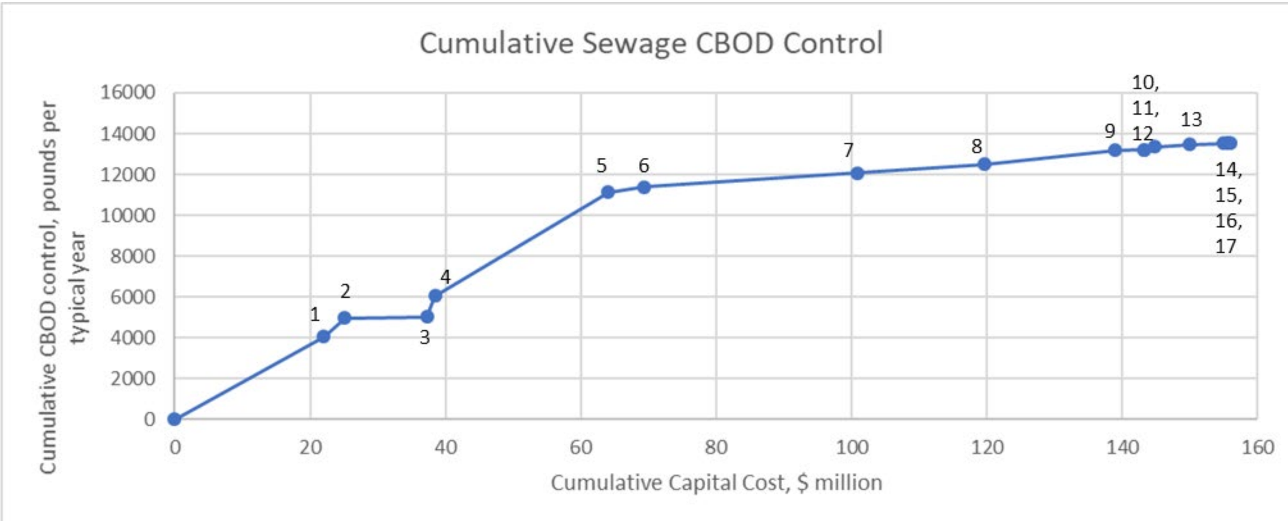


FIGURE 8-6. Cumulative Sewage CBOD Controlled Associated with Prioritized IWWIP Project Capital Costs

CHAPTER 9 – PUBLIC ENGAGEMENT AND PARTICIPATION

9.1 SUMMARY OF SECTION

Lakewood has prioritized public engagement in the development of this plan. Every available communication channel and tactic has been used to ensure that citizens and business owners have information about the plan, but more importantly, they have avenues to provide input into the plan and information that allows them to take action to help resolve inflow and infiltration issues on their own property.

Starting in 2015, Lakewood established a stakeholder involvement process that involved publicizing the issue. Opportunities to learn more were given via social media, traditional media and the City of Lakewood website. Lakewood established an advisory committee to provide feedback on options for addressing this issue, hosted public meetings to solicit feedback from the larger community, and used the public's preferences to shape the plan. Lakewood's public engagement efforts were in concert with and in fulfillment of Elements 3 and 4 of EPA's Integrated Planning Framework.

Lakewood's engagement effort was accomplished in two phases. The first was focused on the establishment of an advisory task force and informing and educating the broader public. After a period of time, during which Lakewood implemented a series of pilot projects, the city developed a second phase of engagement. Phase 2 engagement continued to inform and educate but identified a more robust engagement effort designed to pull in as many citizens and stakeholders as possible to receive input as this plan was being developed.

The result is a highly engaged public that is keyed into the city's solution options, a goal of EPA's Integrated Planning framework. The public involvement efforts showed that residents and business owners are strong advocates for solutions that prioritize affordability and limit disruption in their dense neighborhoods while emphasizing the importance of protecting the environment and meeting regulatory requirements.

9.2 GOALS

This section presents Lakewood's approach to municipal and public participation in the development of its Integrated Wet Weather Improvement Plan.

Successful implementation of any integrated plan depends on having the support of the community. If the public and elected officials have a shared vision for integrating wastewater and stormwater management with land use planning, then successful funding and implementation are more likely to follow.

Lakewood's IWWIP goals include the following:

1. Meet or exceed NPDES permit requirements.

2. Comply with CSO policy.
3. Foster public understanding of the need for this plan; solicit public preferences; maintain positive working relationship with public; gather support for implementation.

Public Input Goals During Phase 1:
1. Inform and engage the public about Lakewood's storm and sanitary sewer infrastructure needs.
2. Inform and engage the public on overflows.
3. Inform and engage the public on green and grey infrastructure options.
4. Solicit feedback from public on options for reducing overflows in Lakewood.

Public Input Goals During Phase 2:
1. Elicit community preferences regarding overflow control approaches, program pace, and affordability.
2. Increase community awareness of the city's efforts to address regulatory, environmental and financial challenges related to control of sewer overflows.
3. Provide a way for residents and businesses to advocate on their behalf to prioritize a solution that is the most affordable and least disruptive to the community.
4. Solicit feedback from public on their preferences for overflows prioritization.
5. Solicit feedback from public on their preferences for different funding options to pay for improvements.
6. Solicit feedback from public on their preferences for work on private property.
7. Solicit feedback from the public on ability to pay and affordability concerns.

9.3 Balancing Public Input and Technical Analysis

While the IWWIP must be based on science (such as: hydrology, water quality, and hydraulics), technical analysis cannot be isolated from stakeholder understanding while still expecting the best implementation. Accommodating smart growth and development in Lakewood's very developed landscape (approximately 70 percent impervious) is a balancing act involving planning, engineering, and public input into decision making.

Achieving integration of the engineering, planning, and ecological perspectives was initiated using communication strategies to coordinate data collection, modeling, and analysis. The results of the models were used in working sessions with the public and stakeholders, so the information could be used in feedback efforts.

Lakewood has continually sought input from the community and will continue to do so. The city wants residents and businesses to understand Lakewood's efforts to update its stormwater and sewer systems to meet the requirements of the Clean Water Act and to provide input on actions private property owners can take and to understand funding needs. The city will maintain effective communication between the various public and municipal participants, which will directly impact long-term planning and success of wet-weather controls.

9.4 LAUNCHING 'CLEAN WATER LAKEWOOD: REBUILDING THE PIPELINE TO OUR FUTURE'

Public engagement efforts began in March 2015 with discussions about the options to obtain public input on CSO control strategies between the mayor's office and the Department of Public Works.

Lakewood recognized that it needed its citizens to understand the intricacies of the issue, so a comprehensive communications strategy was developed. Lakewood launched "Clean Water Lakewood: Rebuilding the Pipeline for Our Future" (CWL). A logo (Figure 9-1) was developed so that continuity of subject matter could be enhanced. Articles were placed on the city's website, newspaper, Facebook page, and on Twitter asking for volunteers for a task force that would meet regularly and be dedicated to discussing how Lakewood could improve its water infrastructure and reduce pollution into Lake Erie and Rocky River (news articles compiled in Appendix 9-1).

FIGURE 9-1. Clean Water Lakewood's logo.

In the spring of 2015, 25 people showed interest in joining CWL. A core group of 18 people committed to monthly meetings. CWL meetings were scheduled from 7 to 9 p.m. on the third Tuesday of every month starting in July 2015 and ending in May 2016.

Citizen task force volunteers included people who cared about local water quality; individuals interested in green design and reducing stormwater runoff; civil, mechanical and environmental engineers; urban planners; local business owners; and a microbiology student.

In addition to Lakewood's citizen volunteers, Lakewood employees also attended task force meetings, including representatives from the mayor's office, Department of Public Works, Housing and Building Division, Planning Department, and City Council.

A significant goal for the city and the CWL task force was to begin public participation early in Phase 1 of the IWWIP process and continue it indefinitely. In Phase 1, the city started informing the public about CSOs, regulatory requirements and possible solutions (Table 9-1). This public information effort has continued into the detailed development of Phase 2 of the plan.

After the initial introductory meeting, two field trips were scheduled for the task force. The first included a complete tour of the Lakewood WWTP and nearby CSOs. The second field trip was an interactive tour of the Cleveland Metroparks' Watershed Stewardship Center in Parma, Ohio, a part of West Creek Reservation.

TABLE 9-1. Topics covered during monthly meetings.

SESSION THEME	SESSION PURPOSE
Introductory meeting: CSO challenge	Set the tone for the meetings, introduce everyone, explain overflows
Tour of WWTP	To learn how the treatment plant works, show them where some overflows occur when it rains, discuss high rate treatment
Tour of Watershed Stewardship Center	To learn about effectiveness, maintenance, and challenges of various types of green infrastructure installed
Clean Water Act	To learn about NPDES permits and why Lakewood has one; Erm Gomes, and Brianne Ciccone, of OEPA's Northeast District Office gave overview of NPDES program
Source control on private property: infiltration and inflow	To learn how homeowners play a role in reducing volume of water going into sanitary sewer
Green infrastructure	To understand the advantages and disadvantages of various green infrastructure options for addressing CSOs
Lakewood's vision	To understand how this IWWIP might fit into their community vision
Modeling suggestions for section of Lake Ave.	To discuss preferences for reducing CSOs in example study areas. These were 4-person breakout groups focusing on a specific neighborhood; suggestions to be modeled were based on knowledge of system
Modeling suggestions for Larchmont Ave.	
Modeling suggestions for Birdtown neighborhood	
Modeling suggestions for Parkwood Ave.	
Modeling results for Lake Ave.	Reviewing modeling results with each group, what was successful, what was not
Modeling results for Larchmont Ave.	
Modeing results Birdtown neighborhood	
Modeling results for Parkwood Ave.	
Discussing results and take-aways	Entire large group meeting to share their understanding of the results and what it means for future planning

The first six monthly meetings were focused on education, and then starting in December, participants broke into four smaller groups, each focusing on a different street or neighborhood in Lakewood, including: Larchmont Avenue, Lake Avenue, Parkwood Avenue and Birdtown.

The reasoning behind choosing each of these study areas is as follows:

1. **Larchmont Avenue**: A combined sewer constructed circa 1905. Overflow at the end of Larchmont is similar to 12 other locations along Detroit and Madison Avenues.

2. **Lake Avenue**: A combined sewer system that connects to a storm sewer. A regulator directs low flow to the interceptor for treatment; higher flows are discharged as a CSO. This area is representative of many areas along Lake Avenue. and Clifton Boulevard. (Note: in 2018

Lakewood completed a storm sewer improvement that significantly reduced CSO overflow volume and pollutant loading.)

3. **Parkwood Avenue**: An over-under sewer that discharges to a sewer on Detroit Avenue. This sewer on Detroit Avenue was constructed in 2007 but regularly overflows into storm sewer on Detroit Avenue. This overflow is similar to seven other overflow locations in Lakewood.

4. **Birdtown**: Combined sewers connected to West 117th Street. Most dry-weather flow goes to Lakewood's WWTP, but some wet-weather flow goes to NEORSD's Westerly WWTP. Additionally, there are two overflows on Madison Avenue. This neighborhood used to be a company town for Union Carbide and has been the focus of specific planning initiatives by Lakewood.

These four task force subgroups received detailed information about the sewer systems, water volumes, soil conditions, and known infrastructure issues in each of these neighborhoods. Using this information, the subgroups were better prepared to suggest green and grey infrastructure modeling ideas for CT Consultants to model, with the goal being to control overflows consistent with CSO policy.

The subgroups brainstormed and came up with thoughtful and creative solutions. Summaries of the modeling suggestions were emailed to the subgroup members to ensure what they asked for was captured. After determining how much volume was captured using their suggestions in the model, the results were shared both in person and via email. With these results the participants were able to see what could be successful at reducing overflows, and what likely would not.

9.5 Phase 2 Public Engagement - Providing Forums for Public Feedback on 'Clean Water Lakewood: Rebuilding the Pipeline to Our Future'

In September 2018 Lakewood developed a Clean Water Lakewood Community Engagement Plan (Appendix 9-1). A summary of portions of that plan are included in this section.

TASK FORCE WORKSHOP #1

Meeting Date: October 23, 2018 **Number of people in attendance:** 45

Meeting Topic: The focus of the workshop was to help participants learn by discovery and exchange and bring them up to speed on the current state of the city's planned response in developing Lakewood's overflow control plan.

This workshop set the stage for the Joint Task Force Workshop #2 on Nov. 15 where workshop participants would focus on providing input that would feed directly into the decision-making process through facilitated exercises. The two workshops were designed to allow participants to "dig in" to this issue with others who are committed to the process and the Clean Water Lakewood efforts. In designing the workshop, it was expected that participants would have differing opinions, but what they produced would be used in the city's overflow control plan submittal, not just documented for the record.

Participants:
- Members of Clean Water Lakewood Task Force
- Members of Lakewood's Resiliency Task Force
- Members of Lakewood's Planning Commission
- Lakewood city staff, City Council, and IWWIP Phase 2 consultants

Description:
At this workshop, participants received a briefing to ensure that all participants understood the history and the current state of the city's response to managing combined sewer overflows and the current and potential future regulatory environment.

Workshop Goals:
1. Raise awareness and provide information to Lakewood's most engaged citizens
2. Foster discussion and progress on receiving community feedback on common ground related to Clean Water Lakewood options
3. Get participants engaged in this issue and in finding workable, sustainable solutions

Implementation:
Lakewood staff obtained participants' agreement to the agenda, process and ground rules at the beginning of the meeting. They explained how the Oct. 23 and Nov. 15 workshops were related and the goal for each. Respect was shown for all perspectives. Participants understood how the workshop results would be used in the process of developing the IWWIP.

Documentation:
A record of the presentation, attendance, questions and answers, and any outstanding questions were provided on Lakewood's website (Appendix 9-1).

TASK FORCE WORKSHOP #2
Meeting Date: November 15, 2018, **Number of people in attendance:** 45

FIGURE 9-2. Small group discussions at the Task Force Workshop

Meeting Topic: The focus of the November workshop was to break into small groups assisted by assigned facilitators to share perspectives, identify issues, prioritize choices and issues, and evaluate alternatives (Figure 9-2). After each round of discussion, individual participants were asked to use "dot voting" to express their views on questions that included outfall prioritization, private property mitigation, tolerance for disruption from construction activity and affordability concerns.

This workshop built on the Joint Task Force Workshop #1. The two workshops were designed to allow participants to "dig in" to this issue with others who are committed to the process and the Clean Water Lakewood efforts.

Participants:
- Members of Clean Water Lakewood Task Force

- Members of Lakewood's Resiliency Task Force
- Members of Lakewood's Planning Commission, Architectural Board of Review (ABR), Board of Zoning Appeals, Audit Committee, Community Advisory Committee and various other boards and commissions
- Lakewood city staff, City Council, and IWWIP Phase 2 Report consultants

Description:
At this workshop, participants broke into small groups and worked on pre-designed assignments assisted by a facilitator. At the end of the workshop the work of each group was documented and became the basis for the Community Conversations event on December 4, 2018.

Workshop Goals:
1. Foster discussion and progress on receiving community feedback on common ground related to Clean Water Lakewood options
2. Get participants engaged in the project and in finding workable, sustainable recommendations
3. Narrow down options and seek input on disruption, equity and total cost tradeoffs.

Implementation:
Lakewood staff obtained participants' agreement to the agenda, process and ground rules at the beginning. They explained how the Oct. 23 and Nov. 15 workshops were related and the goal for each. Respect was shown for all perspectives. Participants understood how the workshop results would get used in the process. Lakewood sought consensus and described the next step, the Community Conversations event on Dec. 4, and sought volunteers for that effort to help engage the larger community.

Documentation:
A record of the presentation and dot voting results are provided here (Appendix 9-1).

COMMUNITY CONVERSATIONS
Meeting Date: December 4, 2018, **Number of people in attendance:** 54

Meeting Topic: The purpose of the Community Conversations effort was to engage City of Lakewood residents and business owners in discussion about the city's compliance with the Clean Water Act. This forum was focused on obtaining input specifically on the community's understanding of the issue and preferences for private property mitigation approaches and funding strategies.

Community Conversations Goals:
1. Educate participants regarding Lakewood's challenge to update its stormwater and sewer systems to meet requirements of the Clean Water Act.
2. Identify areas of consensus regarding burden of private property improvements related to remediation.

3. Build understanding related to the need for future revenue increases to accommodate public property improvements.

Recruiting participants:
The city desired a large attendance base for this effort, and recruitment was important to accomplish this goal. The following activities were done to maximize attendance:

- Email invitations from the mayor and City Council
- Email invitations to all the city's boards, commissions, and task forces
- NextDoor neighborhood group posting
- Lakewood Life IWWIP article and event invitation
- Lakewood City Schools electronic newsletter
- Website media release and calendar posting
- Email invitations to stakeholder groups
- News media release via website
- City's social media channels (Facebook, Twitter, Instagram)
- Inclusion in community Block Club Group eNewsletters
- Email invitation to Lakewood landlords via constant contact (approximately 1,500 unique email addresses)
- Email invitation to community, non-profit and faith organizations via PR Roundtable
- Hard copy flyers at high traffic areas such as libraries, drug and pet stores

FIGURE 9-3. The Mayor addresses the public at the Community Conversations meeting

Meeting Format

Participants were directed to tables. Each table had a facilitator and a recorder. The facilitator was asked to assist with the program, discussion and exercises.

At the beginning of the meeting an overview of the city's compliance with the Clean Water Act and the challenges of meeting the Act's regulatory requirements was provided (Figure 9-3). Participants were told how this forum would be used to update the city's IWWIP.

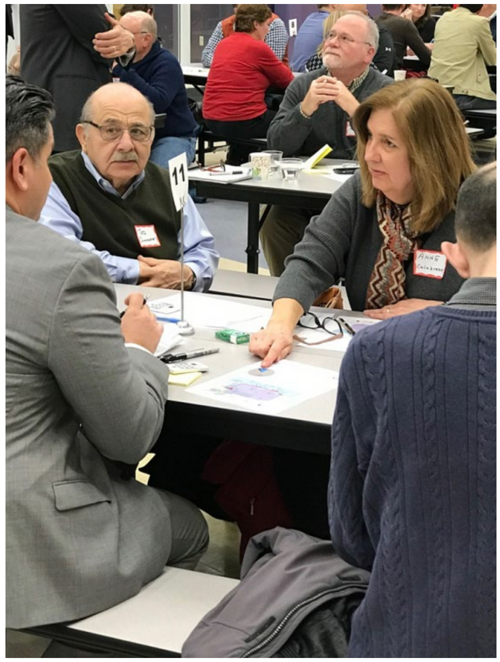


FIGURE 9-4. Table discussion at the Community Conversations meeting

The forum focused on two main activities centered on private property owners' impact on Lakewood's Clean Water Act regulatory strategy and revenue needs for infrastructure investment to meet regulatory requirements.

To provide for anonymity and engaged participation in this setting Lakewood used a combination of interactive polling and true/false statements to help facilitate participant learning and to avoid having some vocal participants influence others.

The first part of the activity used true/false statements and participants will be asked to vote whether they believed the statements to be true or false and then discuss the results. After this activity, staff/consultants reviewed the statements with participants, explaining why each statement was either true or false and providing examples of the City of Lakewood's involvement in each statement area.

The second part of the activity included multiple-choice questions that were projected onto a screen. Interactive polling allowed for live, real-time polls of audience members with questions embedded directly in the presentation. Participants used a keypad to access the poll. This software allowed the facilitator to track the poll results by the number of responses received. When the poll is closed, the results were projected in a graph for all participants to see the results.

After the two main activities, participants heard a short presentation discussing the city's identification of private property solutions intended to bring the city to a higher capture and treatment rate for all water in a typical year and a short discussion of the potential costs of these private and public projects. This presentation was followed by an open table discussion (Figure 9-4) with a facilitated activity at each table designed to address the following questions:

- What had real meaning for you from what you've heard? What surprised you? What challenged you?
- What else do you think the city can do to protect against combined sewer overflows?
- What do you think property owners can do to minimize and remediate stormwater and sewer cross contamination at the individual property level?
- Given the need for revenue for future investments in infrastructure, how do you perceive this problem and the best solution?

Report Out and Evaluations

Group facilitators reported out at the end of the session on the outcome of group activities by summarizing their tables' discussions from the true/false statements and/or ideas and suggestions resulting from the open table discussion. Meeting participants were asked to participate in the Open House on Jan. 16.

At the end of the meeting, participants were asked to complete an evaluation form for feedback on the meeting and process. Summary of the December meeting in included in Appendix 9-1.

COMMUNITY OPEN HOUSE

Meeting Date: January 16, 2019, **Number of people in attendance:** 90

Meeting Topic: The City of Lakewood hosted a Community Open House at the Lakewood High School Cafeteria. The open house was designed to be self-directed to a large degree. Participants stopped by at their convenience and visited the information stations of greatest interest to them. They talked to staff members and shared their individual comments and questions (Figure 9-5).

Goals of the Community Open House

1. Improve public understanding of the stormwater and sewer system and the city's response to Clean Water Act regulations.
2. Inform the public by getting input on specific questions related to private property remediation and potential rate and affordability impacts.
3. Explain complex points in an informal setting allowing for one-on-one discussion.

FIGURE 9-5. Joe Beno, Director of Public Works, answers a resident question

Promotion
The following tactics were used to help build awareness of the open house:

- Email invitations from the mayor and City Council
- Email invitations to all the city's boards, commissions, and task forces
- Lakewood Life IWWIP articles - all city newsletter delivered to 29,300 households/businesses
- Email invitations to those that participated in the workshops and community conversation events
- NextDoor Neighborhood Group postings
- Email invitations to stakeholder groups
- Press releases to traditional news media
- City's social media channels (Facebook, Twitter, Mayor Blog articles)
- Inclusion in neighborhood Block Club newsletters
- Invitation to youth groups (teens and young adults) through outreach to Lakewood High School Principal
- Invitation to community, non-profit and faith organizations
- Inclusion on the city's website

- Inclusion in the city water customer's water bill
- Request partner organizations to help promote community open house (LakewoodAlive, Chamber of Commerce and Lakewood City Schools)
- Other community events – Promotion of IWWIP topics at Summer Solstice event
- Invitation to Lakewood Landlords via constant contact invitation (approximately 1,500 unique emails)
- Facebook Live streaming during the event to attract additional participants

Documentation

Comment forms were provided to participants at the event to help participants provide useful information. At several stations participants were asked for their input on specific topics. Attendee sign-in sheets were used to provide a basis for building a mailing list. A summary of the January Open House is in included in Appendix 9-1.

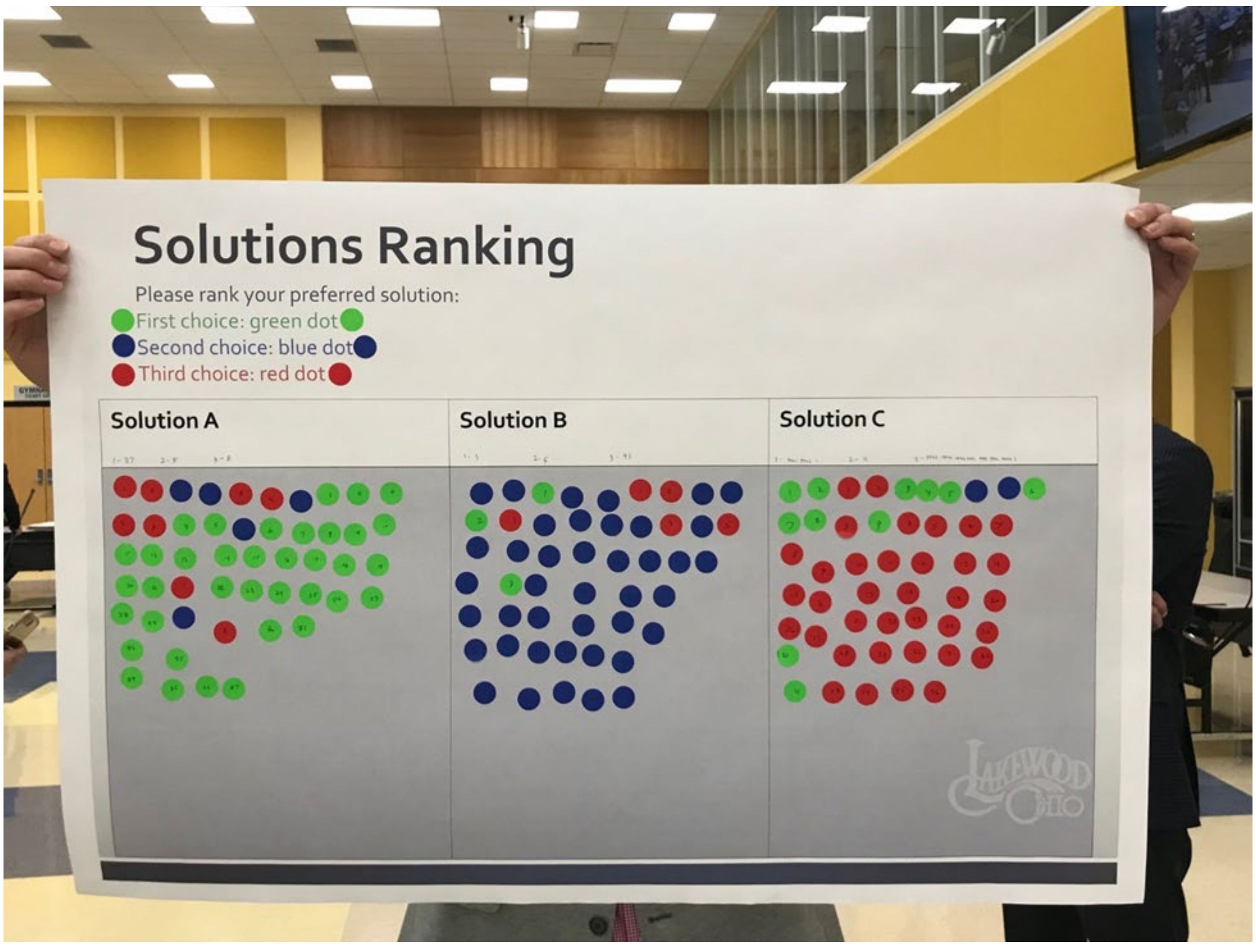


FIGURE 9-6. Results of public vote on solutions

9.6 MEDIA OUTREACH

Lakewood is continuously trying to foster an educated and engaged group of citizens who will help communicate to the broader community, alongside media outreach the city is publishing CSO and NPDES permit requirements. These measures are meant to inspire local support of various control measures, once they are selected, and the costs associated with them.

A concerted effort was made to keep the rest of Lakewood informed of what CWL was doing. Media outreach included the following avenues:

<u>Social media:</u>
- Facebook
- Twitter
- Instagram

<u>Newspaper:</u>
- The Plain Dealer
- Cleveland.com
- Sun Newspaper
- Lakewood Patch (AOL)

<u>Clean Water Lakewood website:</u>
- onelakewood.com/cleanwaterlakewood
- Newsletters/print and electronic:
- Information and flyers included with water bill
- Block Club eNewsletter (70+ block clubs)
- Lakewood City Schools school newsletter
- LakewoodAlive eNewsletter
- eNewsletter to Lakewood landlords (1,500+ unique emails)
- Flyers at libraries, YMCA, and high traffic stores such as drug stores

The CWL website was updated after each meeting ensuring that handouts and meeting summaries were available for all to see.

CWL presentation materials from the January 16, 2019 Open House were displayed in the City Hall Auditorium/Council Meeting Chambers for five weeks (January 17-February 22, 2019). Poster materials were used during City Council discussions about the IWWIP and were available for residents to review during city council meetings and other community meetings such as the Landlord Training session on February 12, 2019 which had 200 attendees.

The CWL website was updated after each meeting ensuring that handouts and meeting summaries were available for all to see.

CWL presentation materials from the January 16, 2019 Open House were displayed in City Hall Auditorium/Council Meeting Chambers for five weeks. Poster materials were used during city council meeting discussions about the IWWIP and were available for residents to review during community meetings such as the Landlord Training session on February 12, 2019 which had 200 attendees.

9.6.1 Other Community Outreach

Community outreach on this issue is done regularly by the mayor and his administration. Whether the audience is a block club, Kiwanis, Rotary, LakewoodAlive or the Lakewood Chamber of Commerce, the subject of sewers, Clean Water Act Compliance and the protection of our greatest resource, Lake Erie, is always a part of the conversation.

Over the last eight years Mayor Summers has continually engaged the community through:

1. **Eight *State of the City* addresses** during each of which he stated that one of the biggest issues facing this community was compliance with the Clean Water Act.

2. **96 *Listening to Lakewood* forums** which take place at 5:30 p.m. on the second Tuesday of every month. Residents may drop by to talk about any topic of their choosing. Mayor Summers takes these opportunities to update those who attend about matters of concern in the city. While sewers may not have been mentioned at all 96 of these gatherings it was a topic of conversation for some period of time at the majority of these forums.

3. **Mayor Summers visits elementary school classes and hosts elementary school classes at city hall, to talk about what the city does and how it operates.** The Mayor takes these opportunities to talk to the youngest residents about the importance of our sewers and protecting our Great Lake (Appendix 9-1).

One of the greatest investments heightening community awareness about the need to protect our Great Lake was the investment the city made in Lakewood Park. The creation of the Solstice Steps has brought enjoyment of the lake to the residents of Lakewood. It has awakened the desire of residents to protect this resource. Arguably the message about the need to comply with the Clean Water Act of 1972 by updating our city sewer infrastructure has been better accepted by the residents because of this investment a few years ago.

9.7 Summary of Public Input

The public input received during Lakewood's many years of engagement provides a critical element that shapes the IWWIP. As shown above, the active engagement provided many points for specific input. As important, however, were the questions, comments and concerns expressed by residents about what relevant information they desired. This aspect was critical to advancing the depth of information presented at each step of the engagement process. Lakewood plans to continue its public engagement at public events, at meetings of civic groups and through its newsletters and social media as the IWWIP is implemented.

The public input provided includes these summary points:

1. **Affordability is top of mind**. Residents in every engagement session stressed the challenges that their community faces in terms paying for needed improvements. Residents recognized that their community is economically diverse and that many struggle with cost of living issues now. This was particularly evident during a session when participants were asked about ability to afford a monthly increase and respondents overwhelmingly stated that increases beyond $10 a month would be unreasonable.

   Participants showed strong support for programs that provide affordability assistance to lower income residents. More than two-thirds of participants support a bill assistance program for income-qualifying residents and 83 percent of respondents supported a low-income program to fund private property improvements.

   Input received stressed that all projects should get the "best bang for the buck" in terms of public health and environmental improvement.

2. **Tolerance for public health and environmental improvement of system impacts was included in each engagement session. Basement backups are the worst outcome cited, and the risk of creating them must be avoided during plan implementation**.

   Public suggested CSO 052 discharging to the Rocky River should be addressed as a priority because of pollutant loading, public recreation in the Rocky River, and because this effort is the most affordable and least disruptive control technology on city-owned property. This feedback was supported by an exercise where participants were asked whether they would prioritize reducing pollution flowing to Rocky River or Lake Erie. Three times as many respondents prioritized the Rocky River over Lake Erie. Lake Erie discharges were prioritized based on pollutant loading, with CSO 059 highest in priority.

3. **There is some public interest in city-supported private property improvements but only where they deliver demonstrated deliverable results.** Improvements on private property are intrusive and if mandated must demonstrate that they will result in environmental improvement. Participants overwhelming rejected a suggestion to make improvements to private property mandatory but would support the city providing incentives to residents to make improvements on their property.

   There was recognition that some property owners have already made improvements and residents wanted to be sure that those property owners were somehow compensated should the city put in place an incentive program.

Creating a "time of sale" program requiring mitigation efforts when a property sells would likely take a concerted effort to build community support around this idea. This strategy received as much negative feedback as it did support from participants.

4. **Changes to the rate structure must be equitable. Rates must stay affordable and predictable.** Predictability allows landlords to absorb rate increases into rents and still have capacity to invest in property. Rates based only on water usage are not sustainable, and not equitable to fund a wet-weather improvement plan. The addition of a new impervious-area based charge added to monthly bills was preferred over a new fixed fee because participants felt it was more fair and could help incentive property improvements.

5. **The level of disruption to communities and neighborhoods during project work was a key area of interest.** Residents overwhelmingly said they wanted to integrate sewer upgrades with other planned work and incorporate additional amenities like traffic calming measures, landscaping upgrades, and burying utility lines.

   Participants in engagement sessions cited concerns for small businesses that could potentially have access challenges for long periods of time and the economic impact of that type of construction work occurring in commercial areas.

   Lakewood is a densely developed city, and participants are keenly aware of the level of disruption that can occur with work happening in their neighborhoods. While residents understood the need, they stressed that work should be highly integrated to reduce the number of times they have to endure disruption.

6. **Ongoing public education is critical to raise awareness on the public and private property issues facing Lakewood.** Participants expressed surprise at the level of needs for private property mitigation in their city, so this should be a focus for ongoing communication. One of the key opportunities for communication is connecting Lakewood residents to ways they can mitigate drainage issues as other work is being done on their property.

   Each engagement session gained new participants. The last open house session had numerous participants that were new to the issue and expressed an interest in learning more.

CHAPTER 10 — LAKEWOOD'S INTEGRATED WET WEATHER IMPROVEMENT PLAN

Based on the investigations summarized and reported in the 2019 Phase 2 IWWIP report, the City of Lakewood adopts this Integrated Wet Weather Improvement Plan and schedule.

This IWWIP will achieve compliance with the Clean Water Act and Ohio law. This IWWIP complies with all requirements of 33 USC §1412(s) and EPA's June 2012 Integrated Municipal Stormwater and Wastewater Planning Approach Framework.

The IWWIP and schedule were amended by approval of Lakewood City Council on September 26, 2022 to conform to the requirements of a federal consent decree agreed to by the City of Lakewood and entered by the federal district court on January 31, 2023.

PRIORITIES AND PRINCIPLES

To achieve the environmental and public health goals of the Clean Water Act, Ohio law and the city's Community Vision, the City of Lakewood adopts these priorities and principles to guide the implementation of the IWWIP:

1. **Lakewood is committed to sustained sewer system improvement for the betterment of water resources, human health and the protection of economic vitality of the city.** The city's IWWIP priority is to reduce the discharge of pollutants to receiving waters. General stormwater management and general maintenance and operation will follow existing permits and plans.

   Control of Rocky River pollutant discharge via CSO 052 is prioritized higher than other overflows due to pollutant load, recreational use, and opportunity for significant cost-effective measures on city-owned property. Control of Lake Erie discharges are prioritized based on relative mass of pollutant loading.

2. **Capital projects should achieve the greatest water quality and public health improvement for the dollars spent.** Upgrades to the collection system, especially the modernization of over-under sewers, should be integrated with other infrastructure work, such as street repairs and water line renewal, in order to maximize cost efficiencies and minimize disruption.

3. **Basement backups are the worst water and sewer related outcome and reducing risk of backups is a priority.** Lakewood will not undertake, any action under this IWWIP that knowingly increases the risk of basement backups during the normal level of service conditions. Lakewood will continue system monitoring and iterative modeling so that all improvements under this plan, including major capital projects as well as routine manhole separation and invert plate replacements, are documented and incorporated into ongoing analysis so that risk of backups is minimized.

4. **Consistent with the Clean Water Act and Integrated Planning, Adaptive Management of this IWWIP must be maintained.** Adaptive Management is necessary to leverage land use changes, market opportunities, new technologies, changing affordability and access to non-local sources of infrastructure funding.

   As required by the consent decree, Lakewood will prepare an IWWIP update. As part of the update and at other times, Lakewood will receive and consider public input, consistent with the Integrated Planning Framework.

5. **All actions under the IWWIP must remain affordable and equitable.** The IWWIP must remain affordable for Lakewood's sensitive populations, especially the lowest quintiles. The IWWIP must remain predictable to protect affordability and sustain private investment. New rate structures and any systematic renewal of private infrastructure must be equitable.

With these priorities and principles guiding implementation, Lakewood's IWWIP and schedule are set forth below for the first bundle under the consent decree. All remaining IWWIP large capital measures to be implemented after 2033 are prioritized but subjected to review in 2031.

ONGOING IWWIP MEASURES

The following IWWIP measures are applicable at all times:

1. Lakewood will continue its ongoing investment to renew existing infrastructure, at its WWTP and throughout the system, in an integrated and planned approach.

2. Lakewood will maximize land use opportunities and code enforcement for continued wet-weather improvement and green infrastructure development, consistent with the Community Vision.

3. Lakewood will continue its ongoing investigation and iterative modeling and monitoring to optimize system performance, prioritize capital investments and minimize risks of basement backups.

4. Lakewood will perform periodic affordability analyses, to protect ratepayer affordability, especially the lowest quintiles of the population, in order to keep the program sustainable.

5. Lakewood will perform Adaptive Management review of this IWWIP in preparation for the consent decree required IWWIP update and as necessary.

SCHEDULE

Lakewood adopts the following schedule of IWWIP measures:

1. 2019-2033

- Continue all ongoing activities.
- Complete Atkins area private property pilot study and evaluate the cost-effectiveness and prioritization of any private infrastructure requirements.
- Evaluate revised rate structure to include fixed-fee charge and/or impervious-surface charge and credit or incentive regime.
- Complete West Clifton and other Regulator Improvement Projects.
- Complete $23 million High-Rate Treatment Facility for control of CSO 002.
- Evaluate land use requirements for CSO 059 control measure and related land use opportunities and existing facility investment.
- Per consent decree, construct CSO 052 storage facility RRES 1160-1165: Aerial Sewer to CSO Storage. Controlled to no more than 4 untreated CSOs per typical year.
- Per consent decree, construct CSO 059 storage facility.
- Complete sampling pilot study required by consent decree.
- Complete IWWIP Update by December 31, 2033.

2. **Prioritized potential five-year bundles of measures (exclusive of ongoing activities), subject to adaptive management for implementation after 2033.**

Bundle 2: Homewood

- Construct LEWS 1040: Relief to Interceptor picking up all CSOs and manage at CSO 059. No overflow in two-year storm event.
- Construct LEWS 1195: Close off and convey more to Interceptor and manage at CSO 059. No overflow in two-year storm event.
- Construct LEWS 1070: Source Control, Diversion Sewer, Pump Station, Storm Sewer. No overflow in two-year storm event.
- Design Bundle 3: CSO 057 and Detroit Avenue/West Clifton.

Bundle 3: CSO 057 and Detroit Avenue/West Clifton

- Construct LEWS 1130-1135 (CSO 057): Belle storage tunnel, Lakewood Park Storage Basin, if conditions should still require. Controlled to 4 untreated CSOs per typical year.
- Construct RRES 1145: Source Control, Sewer Separation, Regulator Modification, Green Infrastructure. No overflow in two-year storm event.
- Design Bundle 4: CSO 056A&B and Lakeland.

Bundle 4: CSO 056A&B and Lakeland

- Construct LEWS 1150 (CSO 056B)-1155 (CSO 056A): Source Control, Green Infrastructure, Relief Sewer, Regulator Modifications. Controlled to 0 untreated CSOs per typical year.
- Construct LEWS 1180: Source control, relief sewer, storm sewer. No overflow in two-year storm event.
- Design Bundle 5: Remaining Minor Overflows.

Bundle 5: Remaining Minor Overflows subject to IWWIP Update

- Construct LEWS 1225 (CSO 055): Sewer separation. Overflow eliminated.
- Construct LEWS 1110 (CSO 058): Diversion sewer. Controlled to 4 untreated CSOs per typical year.
- Construct LEWS 1045: Bulkhead interceptor connection, add pump station to serve area. No overflow in two-year storm event.
- Construct LEWS 1055-1060: Source Control, Green Infrastructure, Relief Sewer, Regulator Modification. No overflow in two-year storm event.
- Construct LEWS 1285-1295: Relief Sewer, Regulator Modification. No overflow in two-year storm event.
- Construct LEWS 1210: Source control. No overflow in two-year storm event.
- Construct LEWS 1215: Regulator modification. No overflow in two-year storm event.
- Construct LEWS 1220: Source control, Green Infrastructure. No overflow in two-year storm event.

Appendix 10-1 is a copy of the legislation adopted by Lakewood City Council on February 19, 2019, approving the city's Integrated Wet Weather Improvement Plan and schedule.