



INTEGRATED WET WEATHER IMPROVEMENT PLAN

PHASE 1

BINDER 1

- ☐ **Main Document**
- ☐ **Figures**
- ☐ **Tables**



INTEGRATED WET WEATHER IMPROVEMENT PLAN

PHASE 1

City of Lakewood, Ohio

September 1, 2016



ACKNOWLEDGMENT

The City of Lakewood thanks CT Consultants, Inc. for that firm's important technical assistance in preparing for and creating this first phase of the city's Integrated Wet Weather Improvement Plan. Special appreciation goes to CT Consultants professionals **Robert H. Greytak, P.E., Richard J. Iafelice, P.E., and Julia G. Lazar, Ph.D.,** for their valuable input on all aspects of this document.



TABLE OF CONTENTS

BINDER 1

Main Document

Project Team	viii
Chapter 1 – Executive Summary	1
Chapter 2 – Introduction	4
2.1 Purpose	4
2.2 2006 Long Term Control Plan	4
2.3 Lakewood Integrated Planning Process Since 2007	5
2.4 IWWIP Phase 1 Objectives	6
2.5 Regulatory Framework	7
2.6 Phase 1 IWWIP Plan Development Process	8
Chapter 3 – Sewer System Characterization	11
3.1 Introduction	11
3.2 Location and Topography	11
3.3 History of Lakewood’s Sewer System	13
3.4 Hydraulic Characterization	20
3.4.1 Modeling a Single Event	20
3.4.2 Continuous Simulation Model	22
3.5 Pollutant Model	24
3.5.1 Land Use Categories	24
3.5.2 Pollutants within Stormwater Runoff	25
3.6 Typical Year Results	26
Chapter 4 – Public Participation	27
4.1 Summary of Section	27
4.2 Goals	27
4.3 Balancing Public Outreach and Technical Analysis	27
4.4 Launching “Clean Water Lakewood: Rebuilding the Pipeline to Our Future”	28
4.5 Meeting Summaries	32
4.6 Media Outreach	41
Chapter 5 – Receiving Water Characterization	42
5.1 Background on Lake Erie and Rocky River	42
5.1.1 Lake Erie	42
5.1.2 Water Quality Concerns Facing Lake Erie	43
5.1.3 Rocky River	44
5.2 Rocky River and Lake Erie Water Quality Standards	46
5.2.1 Water Quality Reporting	47
5.2.2 Bacteria Monitoring	48
5.3 History Water Quality Sampling of CSOs	51
5.4 References	52
Chapter 6 – Source Control Pilot Study	53

**TABLE OF CONTENTS (CONTINUED)****Main Document (continued)**

6.1 Background to Pilot Study	53
6.2 Recognition of Challenges	53
6.3 Goals of the Program	53
6.4 The Pilot Study Program	54
6.5 Execution of the Pilot Study Program	55
6.5.1 Phase I	55
6.5.2 Phase II	56
6.5.3 Phase III	60
6.5.4 Phase IV	62
Chapter 7 – Enhanced Modeling Methods	64
7.1 Introduction	64
7.1.1 EPA SWMM Low Impact Development (LID) Tools	64
7.1.2 Modeling I/I in Sanitary Sewers	64
7.2 Parcel Level Modeling	66
7.2.1 Existing Conditions of the Pilot Area Sewer System	67
7.2.2 Enhanced Model Concepts	68
7.2.3 Construction Observations from the Pilot Study	70
7.3 Modeling Methods: Developing Approaches	71
7.3.1 Enhanced Model Subcatchments at the Parcel Scale	72
7.3.2 Model for Source Control	73
7.3.3 Green Infrastructure Modeling	75
7.3.4 Assumptions in the Green Infrastructure Model	76
7.4 Modeling Methods: Developing Citywide Approaches	78
Chapter 8 – Potential Control Technologies for Overflows	80
8.1 Control Technologies	80
8.2 Screening of Control Technologies	80
8.2.1 Technologies Required by the NPDES Permit	81
8.2.2 Technologies Considered by Clean Water Lakewood Task Force	82
8.2.3 Green Infrastructure (GI) Technologies	82
8.2.4 Technologies Considered by the Engineering Team	83
8.3 Control Technologies Implemented	83
8.3.1 Technologies Implemented Through Early Action Project Plan	83
8.3.2 Voluntary Implementation of LTCP Technologies	84
8.4 Control Technologies Selected	85
8.5 Proposed Control Technologies for Overflows and Maps	86
Chapter 9 – Preliminary Financial Estimates	106
9.1 Background	106
9.2 Sewer Separation (in Combined Sewer Areas)	106
9.3 Storage Tunnels and Basins	107
9.4 Express Sewers	107

**TABLE OF CONTENTS (CONTINUED)****Main Document (continued)**

9.5 Increased Treatment Capacity	107
9.6 Proposed IWWIP	108
9.6.1 Green Infrastructure Costs	108
9.6.2 Source Control Costs (Over/Under Sewer Areas)	109
9.7 IWWIP Costing Summary	109
Chapter 10 – IWWIP Planning and Continued Implementation	111
10.1 Phase 2 IWWIP Planning	111
10.2 Integrated Planning Tools In Use	112
10.2.1 Lakewood’s Community Vision includes Stormwater Goals	112
10.2.2 Parking Code Update	113
10.2.3 Architectural Board of Review and Stormwater Management	113
10.2.4 Conditional Use Zoning	114
10.2.5 Lakewood Stormwater Ordinance	114
10.3 Active Focus on Stormwater Goals Leverages Green Infrastructure	115
10.4 Additional Green Infrastructure Activities	117
10.4.1 City-Owned Green Infrastructure Installation	117
10.4.2 Training on Green Infrastructure	117
10.4.3 Green Infrastructure Maintenance Planning	119
10.4.4 Example Green Infrastructure Ordinance Language	119
10.5 Public Participation Expands	122

Figures

2-1 IWWIP Plan Development	8a
3-1 Lakewood Location Map	12
3-2 Lakewood Drainage Pattern	13
3-3 Lakewood Interceptor Sewer	14
3-4 Invert Plate Manhole	15
3-5 Map of Combined and Separate Sewers	17
3-6 Example of Dry Weather Flow Calibration	21
3-7 Example of Wet Weather Flow Calibration	22
3-8 Modeled Monthly CSO Activations	23
3-9 Pollutant Calibration Graph Showing First Flush	25
4-1 Clean Water Lakewood’s Logo	28
5-1 Approximate Boundary of Rocky River and Lake Erie Watersheds within Lakewood	42
5-2 Lake Erie and its Drainage Basin	44
5-3 Rocky River Watershed	46
5-4 OEPA 2016 Integrated Report Aquatic Life Monitoring Results	48
5-5 <i>E. coli</i> Sampling Results in 2016 [at Two Nearby Beaches]	50
5-6 Running Geometric Mean <i>E. coli</i> Sampling Results in 2016 [at Two Nearby Beaches]	51
5-7 Mean Concentrations from CSO Outfalls during Quarterly Sampling (2013-2015)	52

**TABLE OF CONTENTS (CONTINUED)****Figures (continued)**

6-1 Source Control Pilot Study Area	56
6-2 Source Control Pilot Study Work Plan Flow Chart	57
6-3 0.5 Inch Rain Event, Pre-Construction vs. Partial Post-Construction	63
7-1 Enhanced Model Methodology	65
7-2 Source Control Pilot Study Area	66
7-3 Typical Private Property Configuration	67
7-4 Initial Parcel Model Development: Understanding Runoff Characteristics [etc.]	68
7-5 Typical Downspout Configurations	69
7-6 Calibrated Hydrograph for Pilot Study Area Existing Conditions	70
7-7a Private Parcel Connections, Actual	71
7-7b Trap Clogged with Sediment	71
7-8 CWLTF Study Areas	72
7-9 Depiction of How Study Areas were Broken Down in Model	73
7-10 Existing Conditions in Over/Under Sewer Areas	74
7-11 Post Construction Conditions for Source Control in Over/Under Sewer Areas	74
7-12a Existing Conditions in Combined Sewer Areas	75
7-12b Proposed Conditions for Green Infrastructure	76
7-13 Existing Conditions Subcatchment Runoff Route	77
7-14 Proposed Conditions Subcatchment Runoff Route	78
7-15 Citywide Approaches for Controlling Overflows	79
8-1 West End CSO Elimination Project Results [etc.]	85
8-2 to 8-22a Proposed Control Technologies for Overflows	100a-kk
10-1 Bioswale at Local Restaurant, Installed in 2014	114
10-2 2016 Postconstruction Stormwater BMP Sites	115a
10-3 Bioswale at Public Park, Installed in 2015	117
10-4 Bioretention Area Inspection and Maintenance Checklist	118-119

Tables

3-1 Lakewood CSOs	18
3-2 Estimated CSO Activations and Volumes in a Typical Year of Rain	23
3-3 Model vs. WWTP DMR Influent Flows and Loadings	26
3-4 Modeled Typical Year Flow and Pollutant Loadings	26
4-1 Topics Covered During Monthly Meetings	31
4-2 Breakout Group Meeting Schedule	38
4-3 Summary of Public Preferences	38
4-4 Results for Larchmont Ave. Study Area	39
4-5 Results for Lake Ave. Study Area	40
4-6 Results for Birdtown Study Area	40
4-7 Results for Parkwood Ave. Study Area	40
5-1 List of WWTPs Discharging to the Rocky River	45



TABLE OF CONTENTS (CONTINUED)

Tables (continued)

6-1 Source Control Volume and Flow Reduction at 50% Construction Completion	63
8-1 Status of Control Technologies Considered	81
8-2 IWWIP Modeling Results after Incorporating Control Technologies	101-105
9-1 HRT Capital Costs	108
9-2 Sewer Separation vs. Green Infrastructure (Construction Only)	109
9-3 IWWIP Phase 1 Conceptual Capital Cost Summary	110
9-4 Conceptual Cost Comparison	110
10-1 Green Infrastructure Practices in Lakewood, Ohio	116

BINDER 2

Attachments

- A. Sewer System Maps
- B. Hydraulic Model Technical Memorandum

BINDER 3

Attachments

- C. Pollutant Model Technical Memorandum
- D. ACTIFO and BIOACTIFLO Pilot Study
- E. High Rate Treatment Basis of Design
- F. Source Control Pilot Study Supporting Documents
- G. Modeling Methods Technical Memorandum
- H. Public Input Documents
- I. Modeling Public Preferences at Catchment-scale Technical Memorandum

BINDER 4

Attachments

- J. NPDES Permit
- K. Overflow Monitor Installation Reports
- L. Miscellaneous Information



PROJECT TEAM

City of Lakewood

Michael P. Summers, Mayor
Joseph, J. Beno, P.E., Director of Public Works
Kevin M. Butler, Director of Law
Jennifer Pae, Director of Finance
Mark K. Papke, P.E., CPESC, City Engineer
Shannon C. Strachan, Exec. Assist. to the Mayor
William M. Crute, Lakewood WWTP Superintendent
Bryce Sylvester, Planning and Development
Brian Shields, P.E., Project Manager
Colin McEwen, Public Information Officer

CT Consultants, Inc.

Robert H. Greytak, P.E., Project Manager
Richard J. Iafelice, P.E., P.S., Source Control Lead
Julia G. Lazar, PhD, Project Coordinator
Christopher P. Rybak, P.E., Chief Modeler
Lene C. Hill, P.E. LEED, Modeler
Mark R. Delisio, P.E., Modeler
Phillip W. Kiefer, P.E., Modeler
Kristin M. Hopkins, AICP, Planner
Joyce M. Bond, Registered Landscape Architect
Kevin E. Ring, P.E., Programmer/Modeler
Matthew McCutcheon, P.E., Modeler
Patricia Vanah, P.E. Modeler
Jennifer A. Brown, Public Policy
George M. Stevens, EIT, Field Services
John F. Kelley, Field Services
James Barber, EIT, Field Services
Justin N. Silvaroli, EIT, Field Services
Timothy McLaughlin, EIT, Field Services

McMahon DeGulis llp

Louis L. McMahon, Esq.



CHAPTER 1 – EXECUTIVE SUMMARY

The City of Lakewood is developing its Integrated Wet Weather Improvement Plan (IWWIP) in keeping with the City of Lakewood's Community Vision. Phase 1 of the IWWIP is premised on a five year effort to characterize its sewer system in detail through comprehensive field investigation, hydraulic modeling, and pollutant modeling. The characterization performed for the IWWIP is unprecedented in Lakewood's history and represents a significant effort in time and expense to obtain the best characterization of its system that is possible.

The IWWIP, which follows EPA's June 2012 Integrated Municipal Stormwater and Wastewater Planning Approach Framework, furthers the city's ongoing efforts to use all planning tools available to integrate stormwater management with wastewater collection management and all city initiatives in order to realize community goals in redevelopment and environmental improvement.

This document details the first phase of City of Lakewood's IWWIP in conformance with the requirements in its 2014 NPDES permit. Phase 1 of the IWWIP includes initial identification and testing of technologies, especially those that may not have obvious impacts on CSO control individually, but when used in concert with other traditional control methods can realize benefits.

The work products associated with the first phase of the IWWIP consist of the following:

1. A comprehensive calibrated hydraulic computer model of all known sewers that compose the city's wastewater and stormwater collection system.
2. A calibrated pollutant computer model of the wastewater and stormwater collection system.
3. A detailed source control pilot study that included corrections for 102 homes within the study area. The study included pre- and post-construction flow monitoring to gauge the effectiveness of the corrections. The corrections also included corrections to defects and cross connections within the public right-of-way.
4. Documentation of an inclusive public participation process involving Lakewood residents who guided the development and direction of the IWWIP.
5. Development of enhanced modeling methods to evaluate source control, green infrastructure, and other technologies at the parcel level.
6. Extrapolating parcel level technologies to similar areas of the city to evaluate their effectiveness for control of overflows.
7. Pilot testing High Rate Treatment (HRT).
8. Developing a Basis of Design for a 35mgd capacity HRT and evaluating its impact in the hydraulic computer model of the collection system.
9. Investigating options for control of flow in the east end of the city which contribute to significant overloading of the city's interceptor at its furthest upstream point on W. 117th Street in a sewer system shared with the Northeast Ohio Regional Sewer District.
10. Integrating the benefits of projects undertaken in the city to reduce overflows since 2007.



Phase 1 of the IWWIP is preliminary, setting the foundation for Phase 2, which will include a detailed alternatives analysis, a financial and financing analysis, and development of a schedule of implementation. The IWWIP Phase 1 plan elements that are to be advanced to Phase 2 include:

1. Instituting a program of source control in areas with an over/under sewer system configuration (significant portions of the city) that consists of redirecting cross connected downspouts, foundation drains, and area drains to the storm sewer system.
2. Instituting a program of green infrastructure improvements in areas with combined sewer areas which consists of permeable sidewalks, driveway aprons, bioretention in the tree lawns, and downspout disconnection.
3. Evaluating controlling flows to the head end of the city's interceptor either through construction of a detention basin upstream of CSO 059 (LEWS1035-A) or redistributing flow within the multiple sewers on W. 117th Street that are separately operated but hydraulically interconnected to NEORS.
4. Advancing the HRT adjacent to the Lakewood wastewater treatment plant (WWTP) to final design and construction.
5. Evaluating sewer separation in areas where green infrastructure is identified as not preferable due to hydraulic impacts from the interceptor or adjacent connected sewers.
6. Hydraulically isolating two small areas north of the interceptor through construction of pump stations where surcharging of the interceptor is causing backup overflows in the local sewers.

The IWWIP also recognizes the improvements made by the city to its collection and treatment system since 2007 including:

- Reducing overflows by performing a sewer separation on part of Edgewater Drive in LEWS1150 (CSO 056) area.
- Achieving success with completion of six Early Action Projects.
- Modifying the MS4 post-construction BMP guidelines to reduce the affected properties from one acre to 8,000 square feet as the city is nearly 100 percent developed in less than one acre lots.
- Reducing runoff from six public parking lots by implementing pervious pavement and bioretention in these areas.
- Increasing the wet weather treatment capacity of the Lakewood WWTP to 40 mgd.
- Performing manhole separation in areas where complete street reconstruction is being implemented or in areas with previous reports of basement flooding issues.

Lakewood has demonstrated in recent years that its collection system is a unique arrangement of more than century-old elements pieced together. Single pipe-combined sewers are intermingled in sewersheds with common trench, so-called "over-under" sewers. Private property infrastructure includes elements that were once but are no longer state of the art. For example, storm lat-



erals have been found to have traps, which over time have clogged, seriously impairing the effectiveness of the stormwater system in keeping flow away from sanitary sewers.

Despite its many unique features, the Lakewood system performs at a very high level. Lakewood, for many years, has invested in capacity of its wastewater treatment plant, such that in wet years it actually treats more wet weather flow than dry weather flow. The Lakewood system treats a very high percentage of the flows and, more importantly, pollutants. The Rocky River is in attainment of aquatic life use standards. The monitored beach in Lakewood shows only three occurrences of being above the *E. coli* limits. Capacity-related basement backups are rare.

The challenge for Lakewood is how to efficiently and cost-effectively update its unique system in a densely populated city that is fully built-out. Lakewood has already achieved significant progress in fully integrating this goal into all its municipal and community functions, as reflected in its Community Vision and multiple new installations of post-construction Best Management Practices. The goal of the IWWIP is to chart the path for Lakewood's continued success.



CHAPTER 2 – INTRODUCTION

2.1 PURPOSE

Since 2007, the City of Lakewood has undertaken efforts to address the challenges of upgrading, operating, and maintaining its century-old, complex sewer system. Lakewood's sewer system is a mixture of combined, separate and over/under sewers that serves a densely-populated, completely built-out community. Lakewood has integrated the goals of wet weather control, environmental improvement and sustainability into many facets of community life, including enshrining them in building and parking codes. Lakewood's community efforts can be readily seen, for example, in its Community Vision available at <http://www.onelakewood.com/community-vision>. Lakewood's integrated efforts have resulted in real environmental improvements by upgrading storm and sanitary sewer collection systems that, despite a unique combination of elements, performs at a high level, reflected in the Pollutant Model in Attachment C.

In 2014, the City of Lakewood was issued National Pollutant Discharge Elimination System (NPDES) Permit No. 3PE00004*QD by the Ohio Environmental Protection Agency (OEPA) regarding discharges to the waters of the State of Ohio from the city's WWTP and permitted CSOs. The city's current permit requires the city to "...develop an Integrated Wet Weather Improvement Plan to address overflows from the combined sewers as well as overflows from the separate storm and sanitary system..." in two phases. Phase 1 is to include a full characterization of the collection system, a planning level alternatives analysis of control alternatives that will reduce the volume and frequency of sewage discharges, and initial design specifications for a High Rate Treatment (HRT) system at the WWTP. Phase 2 shall include a comprehensive alternatives analysis updated to consider results of a pilot separation study (currently completing construction).

This document provides the information, data, and analysis for Phase 1 of the Integrated Wet Weather Improvement Plan (IWWIP) as required by the NPDES permit.

2.2 2006 LONG TERM CONTROL PLAN

This IWWIP builds upon analysis performed for the Long Term Control Plan (LTCP) submitted by Lakewood in May 2006. That LTCP was too narrowly focused. Thomas Bramscher, Chief of the Enforcement Section of the United States Environmental Protection Agency (USEPA), Region 5 stated in a review letter dated July 18, 2007 "*System characterization is critical to development of the LTCP... The data provided, however, does not appear to support adequate characterization of Lakewood's (sewer) system.*" The LTCP focused on the permitted outfalls, and noted but did not address a significant number of flow regulators in the sewer system model then used for characterization, and ultimately, analysis of the system.



The LTCP expressly identified five plan components, and inherently relied upon two others. The five plan components articulated were:

- Construction of a 15 ft. diameter, 3.22 mile long storage tunnel with a 20 mgd dewatering pump station that would impact CSOs 002, 057 and 059.
- Separation of over/under manholes in 59 miles of over/under sewers impacting CSOs 055, 056, and 058.
- Rehabilitation of the interceptor with no direct impact on any CSOs.
- Construction of a 78-inch diameter, 1.58 mile long relief sewer on Madison Avenue that would impact CSO 052 plus the Lewis and Elbur overflows.
- Construction of 15-inch diameter sewer in Detroit Avenue to redirect the West End sewer system to the interceptor that would impact CSOs 053 and 054.

The LTCP calculated that 30 percent of rain ended up in the interceptor, but planned on this being reduced to 10 percent (a 66 percent reduction). Therefore, the sixth component of the plan was significant infiltration and inflow (I/I) reduction program throughout the city. To determine if the target reduction is feasible, a pilot study to compare pre and post-sewer separation was recommended before initiating any design.

A seventh plan component, expansion of wet weather treatment capacity, was identified but not included in the delineation of plan components or in any cost estimating.

Two of the LTCP plan components were sufficiently developed such that Lakewood voluntarily initiated them:

- West End redirection to bring CSOs 053 and 054 into conformance with the CSO policy.
- Source control to reduce levels of I/I (required for most plan components), including a recommendation that source control effectiveness be demonstrated through a pilot study.

As of the submission of this Phase 1 IWWIP, these two components are under construction or have been completed and the impacts of these projects are reflected in this plan. In addition, Lakewood has completed a basis of design for a High Rate Treatment facility to expand wet weather treatment capacity.

2.3 LAKEWOOD INTEGRATED PLANNING PROGRESS SINCE 2007

In addition to the voluntary implementation of the projects noted above, Lakewood, since 2007, has made significant strides in integrating the elements of what EPA now calls the Integrated Planning Framework. This progress is reflected in the following developments:



- Completed an update to the Community Vision, and corollary changes to building, zoning and parking codes, in order to integrate the goals of wet weather management and environmental improvement into all aspects of city decision-making.
- To obtain a complete understanding of its unique system, and to evaluate improvement alternatives that would avoid unintended consequences such as causing basement backups, Lakewood completed a comprehensive sewer system investigation, monitoring, and modeling program in 2011 and 2012. The hydraulic characterization Technical Memorandum (Attachment B) was completed in June 2014 and submitted to the USEPA and Ohio EPA (OEPA).
- Reduced overflows via performing a sewer separation on part of Edgewater Drive in CSO 056 area.
- Achieved success with six Early Action Project Plans (EAPP) which are listed in the city's Administrative Consent Order (refer to Chapter 8 for more specifics).
- The city modified the MS4 post-construction BMP guidelines to reduce the affected properties from 1 acre to 8,000 ft² as the city is nearly 100 percent developed in less than 1 acre lots. This ordinance has impacted numerous private projects, and information regarding them is available in Chapter 10.
- City reduced runoff from six public parking lots by implementing pervious pavement and bioretention in these areas.
- City invested even further in increasing the wet weather treatment capacity of the WWTP to 40mgd, where average daily flow is 7.5 mgd.

2.4 IWWIP PHASE 1 OBJECTIVES

The primary objective of the IWWIP Phase 1 is to outline the potential components of an integrated plan that is built upon a firm knowledge of the intricacies of the city's sewer system by using a calibrated hydraulic and pollutant model and soliciting input from the residents of Lakewood. The IWWIP will enable the city to use all planning tools available to integrate stormwater management with wastewater collection management and all possibilities available under USEPA's Integrated Planning Framework. Phase 1 of the IWWIP includes initial identification and testing of strategies, especially those that may not have obvious impacts on CSO control individually, but when used in concert with other traditional control methods can realize a benefits.



2.5 REGULATORY FRAMEWORK

The city's NPDES permit states the goal of the Phase 1 Integrated Wet Weather Improvement Plan is to:

"bring all sewage overflow discharge points into compliance with the technology and water quality based requirements of the Clean Water Act and Ohio Revised Code Section 6111; to minimize water quality and human health impacts; and to minimize the discharge of pollutants. The Integrated Wet Weather Improvement Plan shall be implemented in accordance with federal policy that states the following: (i) SSOs are prohibited; (ii) Dry weather overflows must be eliminated; (iii) CSOs must be reduced to a level consistent with applicable water quality standards and the federal CSO policy."

This language reflected a collaborative effort between the City of Lakewood and OEPA to craft language in the NPDES permit to incorporate the city's ongoing integrated planning initiatives that are consistent with Federal guidelines.

USEPA's June 2012 Integrated Municipal Stormwater and Wastewater Planning Approach Framework identifies the principals for development of Integrated Plans which includes, among others:

"Evaluate and incorporate, where appropriate, effective sustainable technologies, approaches and practices, particularly including green infrastructure measures, in integrated plans where they provide more sustainable solutions for municipal wet weather control."

"Evaluate and address community impacts and consider disproportionate burdens resulting from current approaches as well as proposed options."

"Provide appropriate opportunity for meaningful stakeholder input throughout the development of the plan."

Lakewood's IWWIP includes all six elements identified in the USEPA's June 2012 Integrated Planning Framework:

- Element 1: Water Quality, Human Health, and Regulatory Issues
- Element 2: Description of Existing Wastewater and Stormwater Systems
- Element 3: Public Involvement and Stakeholder Input
- Element 4: Identifying, Evaluating, and Selecting Alternatives
- Element 5: Measurement of Success
- Element 6: Improvements to the IWWIP



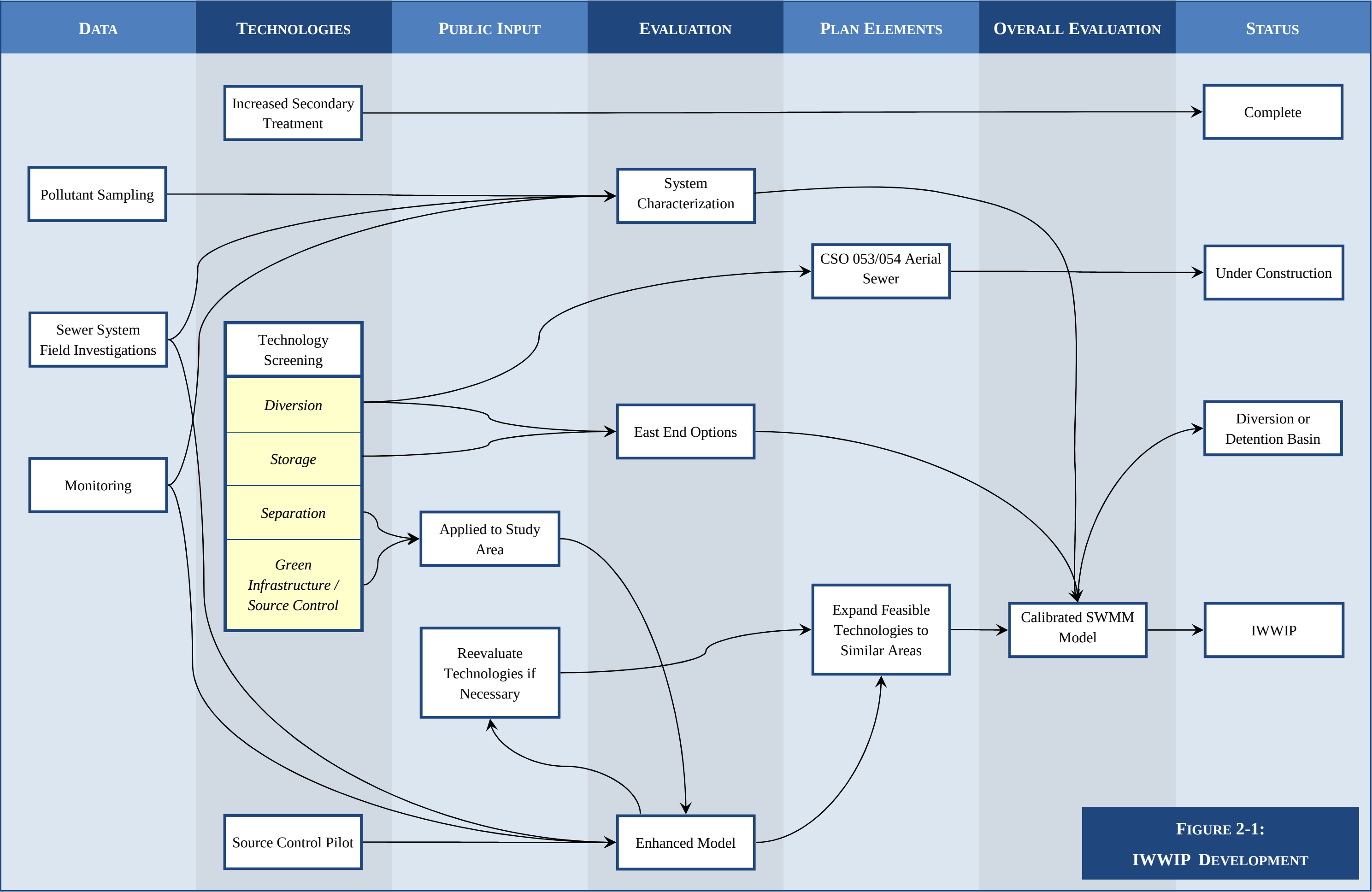
Phase 1 of the IWWIP addresses Elements 1 through 4. Elements 5 and 6 will be addressed in Phase 2 of the IWWIP and beyond.

This Phase 1 IWWIP also recognizes that the city had agreed to an Administrative Consent Order from the USEPA that required implementation of an Early Action Project Plan (EAPP). As of the date of this IWWIP, the EAPP has been completed to the satisfaction of the USEPA and the improvements are integrated into the plan.

2.6 PHASE 1 IWWIP PLAN DEVELOPMENT PROCESS

The IWWIP Plan was developed through a series of tasks that resulted in the elements presented in this document. (See Figure 2-1, following page.) These tasks are identified below:

1. A hydraulic model was developed in SWMM involving significant and intense field work. New sewer system maps were developed to better illustrate types of sewer configurations and locations of overflows.
2. Detailed system investigations and the creation of the hydraulic model revealed that there were more overflows than recognized and analyzed in the LTCP. These additional overflows were located, cataloged, and identified to OEPA. The review of the overflows concluded that the permitted CSO outfalls were not the sole possible locations to control overflows for multiple reasons. In 2015 and 2016, additional monitors were installed at these points to verify whether overflows are occurring at the points.
3. A new approach (IWWIP) was initiated by the city and later incorporated into the 2014 NPDES permit. The permit required the following as part of the IWWIP:
 - a. Design and construct a HRT System as an Interim Control Measure to reduce overflows at CSO 002.
 - b. Elimination of cross connections on both private and public property.
 - c. Develop a comprehensive sewer system map.
 - d. Characterize the sewer system using modeling to calculate hydraulic and pollutant discharges.
 - e. Eliminate illicit connections.
 - f. Develop control alternatives.
 - g. Consider the possible outcomes from the pilot sewer separation study.
 - h. Install monitors at overflows to determine whether overflows are occurring and provide monthly reporting to the Ohio EPA.
4. Some of the elements of the IWWIP were specified in the NPDES and therefore no additional technology alternative evaluation was performed. These elements were:





- a. HRT at the Lakewood WWTP.
 - b. Proceeding with the city's outlined pilot study to eliminate cross connections on private property and consider the effectiveness of the results to control overflows.
5. An enhanced model was developed for the pilot study area that evaluated rain and groundwater impacts from individual parcels in the study area, and then compared the accumulated parcel flow to a sewershed-scaled calibrated model, encompassing the same pilot study area. The goal of this model was to ascertain private property's rain and groundwater impacts on volumes in the sewer system.
6. Public engagement and input commenced in July 2015 with the formation of the Clean Water Lakewood (CWL) task force. The task force was assigned specific areas to review and develop preferences for addressing overflows in various types of sewer system configurations (over/under, single pipe, etc.) using various Control Measures.
7. Utilizing the techniques developed to create the model for the pilot study area, enhanced models were developed on a street-by-street basis to evaluate the task force preferences for their assigned area. In most cases, this required modeling: source control, green infrastructure, separation, and storage. Successful strategies were expanded to other areas in the city with similar sewer configurations. Unsuccessful strategies were reported back to the task force for further changes and consideration. In all cases, revised or expanded task force strategies were successful and incorporated in the plan.
8. The citywide model was updated to include all successful control strategies developed by the CWL task force, as well as those projects identified in the NPDES permit as required (i.e. HRT). The citywide model was the key to evaluating the success of the control strategies as overflows are generated from either upstream and downstream conditions or impacts from hydraulically connected and adjacent sewersheds.
9. In the pilot area, the storm sewers have not been utilized to their full capacity due to plugged private storm lateral connections. Reinstatement of flow from the laterals returned the storm system to its original design intent and new flow was not being added to the storm sewer system.
10. Some small areas were not presented to the CWL task force for evaluation because they are extremely hydraulically complicated and potential solutions were not easily identified. For these areas, the engineering team developed potential separation and hydraulic disconnection for inclusion in the IWWIP.
11. The eastern part of the city, which has predominately combined sewers that share interceptors with Northeast Ohio Regional Sewer District (NEORS), was evaluated



- based on two preferences identified by the task force; storage in the Gold Coast area and potential increased flow to NEORSD. Both options have been incorporated in the model.
12. The citywide model was run integrating all of the recommendations from the CWL task force, anticipated results from the pilot study area, West End diversion, HRT at the WWTP, East End options, and remnant area separation. The resultant overflow volume and activations during a typical year was calculated and the results are contained in Chapter 8.
 13. Preliminary cost estimates were developed for the plan that was effective for the whole city, not simply by overflow location because all controls are dependent on the accumulation of system improvements. The total IWWIP planning level costs were compared to the costs to implement the LTCP (updated to 2016 costs) in Chapter 9.
 14. Additional potential changes to city ordinances to implement, maintain, and perpetuate green infrastructure are being developed and are presented in Chapter 10.



CHAPTER 3 – SEWER SYSTEM CHARACTERIZATION

3.1 INTRODUCTION

Characterization of the Lakewood sewer system consisted of identifying the sewage and stormwater runoff collection system, the overflows, the outfall sewers, and the Lakewood WWTP. Characterization of the collection system (pipe sizes and flow direction) enabled the preparation of a computer model which can simulate flow rates and quantities during dry and wet weather. Flow meters in the collection system were used to calibrate the hydraulic portion of the model. Influent sampling at the WWTP was used to calibrate the model's pollutant input from sewage on dry days. Samplers in the collection system were used to calibrate pollutants within stormwater runoff on wet days. The calibrated model could then be used to analyze the reduction of pollutants for various sewer system improvements.

3.2 LOCATION AND TOPOGRAPHY

Lakewood is located within Cuyahoga County, northeast Ohio on the south shore of Lake Erie. The Lakewood Sewer System is bounded on the north by Lake Erie, on the east and south by the City of Cleveland and on the west side by the City of Rocky River. The collection system serves all of Lakewood and a small portion of Rocky River. Figure 3-1 is a map of Lakewood's boundary.

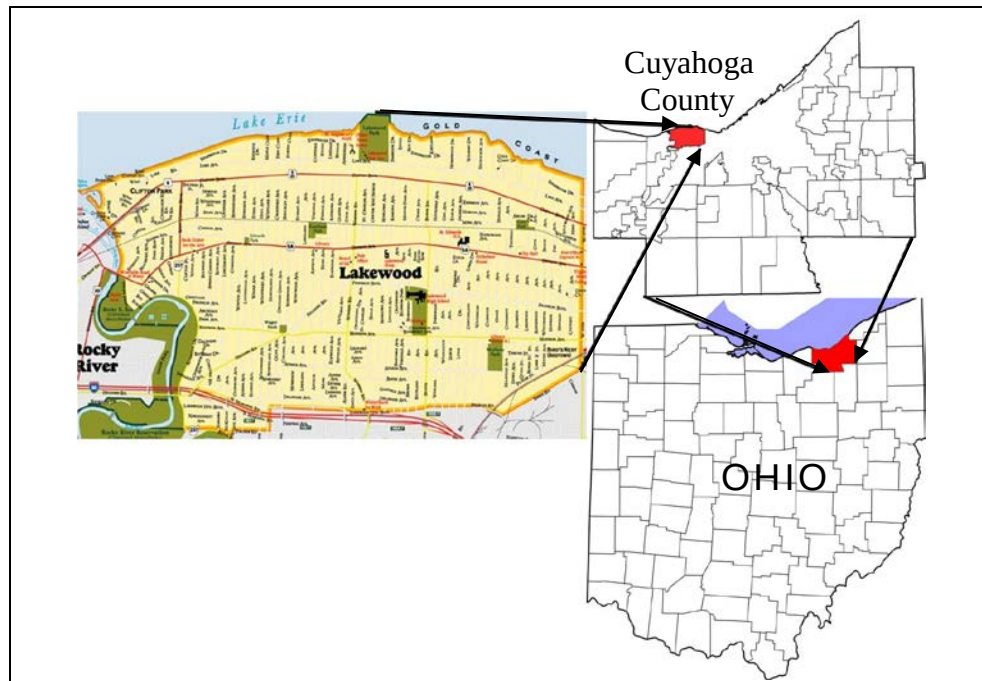


Figure 3-1: Lakewood Location Map

Lakewood sewer system drains to two waters bodies. The eastern and northern portions of Lakewood drain northerly to Lake Erie. The south-western portion of Lakewood drains to Rocky River. This drainage pattern is shown in Figure 3-2 (Source: *Combined Sewer Overflow Long-term Control Plan – May 2006 by Metcalf and Eddy of Ohio, Inc.*)

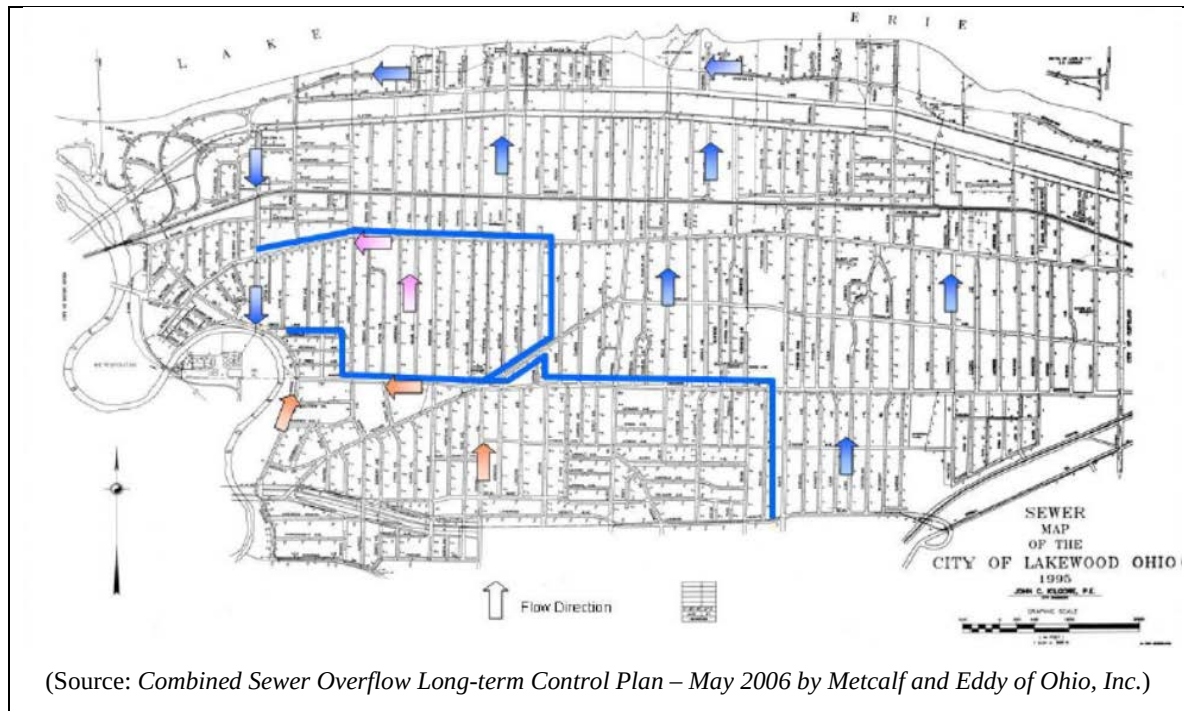


Figure 3-2: Lakewood Drainage Pattern

The last onset of continental glaciation, known as the Wisconsin Advance, is primarily responsible for the soils and topography of Lakewood. When the ice retreated, it left the land relatively flat with the exception of a beach ridge along Detroit Avenue caused by an ancient shoreline of Lake Erie. This flatness enabled construction of a large sewer system with no major pump stations. However, because of the flatness, many of the city's sewers were laid at minimum grade and are prone to settling of solids at low flows.

3.3 HISTORY OF LAKEWOOD'S SEWER SYSTEM

City records indicate that the collection and treatment system began in the early 1900s as separated projects, not as a citywide system. These early sewers were on the east side of Lakewood and they were constructed using a single pipe. The local sewers ran from south to north and they were constructed with vitrified clay pipe (VCP). The larger trunk sewers ran from west to east and were egg-shaped pipes hand constructed out of brick. A large trunk sewer collected all the Lakewood east side flow and ran along West 117th Street from Berea Road north and discharged the flow untreated to Lake Erie.

Lakewood's WWTP has evolved over the years. Construction of the original treatment plant was completed in 1903 on the west bank of Rocky River and was intended to serve a small neighborhood. It had an influent storage tank and a cinder filled filter bed that discharged effluent to Rocky River. Plans were prepared in 1916 to convert the WWTP to have grit removal, primary settling and sludge drying beds. 1938 plans added screen-



ing, new Imhoff (primary settling) tanks, disinfection for the effluent, sludge digesters, enclosed the drying beds, and included a 5,780-foot 36-inch outfall pipe to the Lake Erie shoreline with an additional 1,500 feet of pipe into the lake for a plant re-designed to serve a broader area. 1961 plans demolished the Imhoff tanks and added new primary settling tanks. Aeration tanks and a chlorine contact tank were also added to provide secondary treatment and enhance disinfection. 1980 improvements added a new 72-inch outfall sewer along West Clifton Boulevard and Webb Road into Lake Erie. 1993 WWTP plans changed disinfection from chlorine gas to ultraviolet light. 2001 WWTP plans modified the headworks. The current WWTP processes are detailed in the 2006 *Combined Sewer Overflow Long Term Control Plan*.

After completing the 1916 WWTP improvements, Lakewood started construction of an interceptor sewer to collect dry weather flow and convey it to the plant. Constructed in the 1920s and expanded in the 1930s, the interceptor sewer today starts at the intersection of Edgewater Drive with West 117th Street. It flows westerly to Webb Road, and then turns south along Webb Road and West Clifton Boulevard to the WWTP. The interceptor sewer is the green line on Figure 3-3.

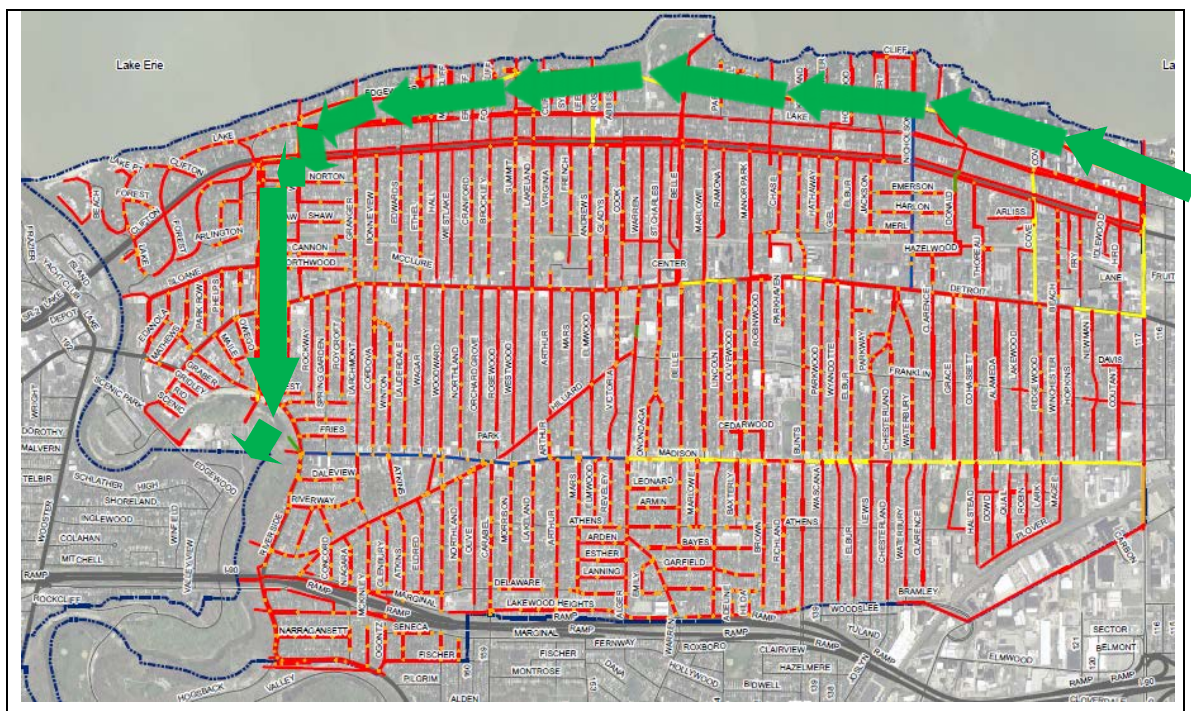


Figure 3-3: Lakewood Interceptor Sewer

The western 75 percent of Lakewood uses two pipes to collect dry and wet weather flow with some single-pipe combined sewers intermingled. The local sewers use VCP in an over/under configuration. The lower pipe collects sewage in dry weather and a portion of runoff in wet weather. The upper pipe transports excess wet weather runoff. As shown



in Figure 3-4, a single manhole provides access to both pipes. An invert plate separates the upper and lower pipes to keep sewer gas from getting out at ground level. The edge of the plate is sealed with cement to keep the gasses in the lower pipe. In order to access the lower pipe, the invert plate has to be physically pried open, breaking all the cement grout. Upon leaving the manhole, re-grouting of the invert plate is necessary. These sewers were mostly constructed in the 1920s and 1930s when it was more feasible to dig a single narrow trench in the rock formation for the two pipes.

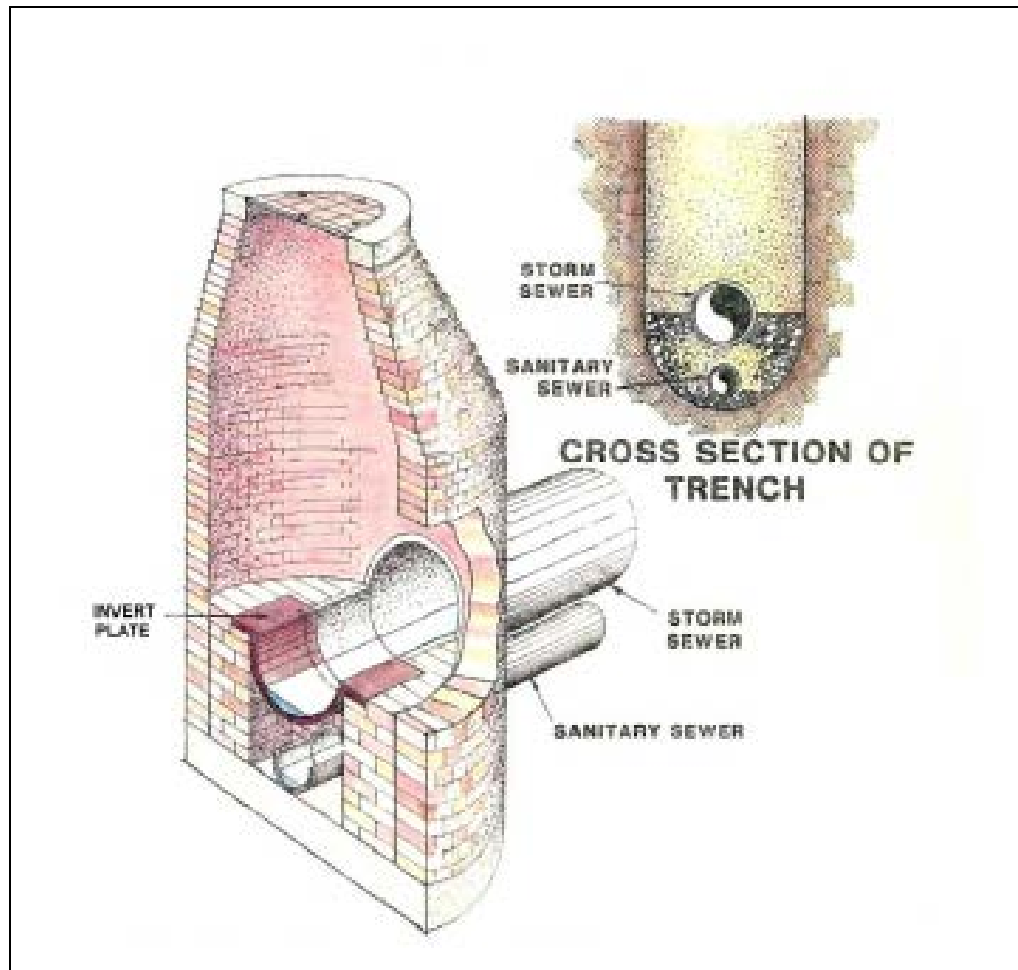


Figure 3-4: Invert Plate Manhole

The pattern of flow in these dual pipe sewers is similar to the single pipe sewers. Local sewers flow from south to north to the main east-west streets (Madison Avenue, Detroit Avenue, and Clifton Boulevard). The Madison Avenue trunk sewer flows west to the interceptor sewer on West Clifton Boulevard. Detroit Avenue has collector sewers that convey flow to five streets (Summit Ave., Gladys Ave., Belle Ave., Marlow Ave. and Nicholson Ave.) which flow to Clifton Boulevard. Three of these (Summit Ave., Belle



Ave., and Nicholson Ave.) continue northward to the interceptor sewer on Edgewater Drive.

The local sewers were built in an era that used mortar to seal pipe joints. Over the last 70 to 90 years, the mortar naturally deteriorates and can allow infiltration and inflow (I/I) into the lower pipe of the two pipe configuration. Infiltration is from groundwater that flows to the sewer trench and into the joints (similar to a French drain). Inflow is from water leaking out of the deteriorated upper pipe joints and into the lower pipe joints. In addition to the leaking joints, a number of the invert plate manholes have had the plates lost or broken throughout the years. These missing invert plates have allowed large quantities of stormwater runoff into the lower pipe. As a result of the increased wet weather flow into the lower pipe, some relief sewers were constructed to mitigate basement flooding.

Beginning with WWTP improvements in the 1990s, Lakewood has prudently invested in additional treatment capacity to address the wet weather nature of its unique collection system. One example of sewers designed to address wet weather flow is the 2001 WWTP plans that replaced the 42-inch aerial sewer with three 48-inch aerial sewers. The three pipes increased the transport capacity from 26 mgd to 112 mgd. Since the average dry day flow to the WWTP is 6.283 mgd, the three 48-inch sewers clearly are designed to convey both sewage and stormwater to the WWTP. Another example is the 2001 WWTP plans that increased the WWTP capacity to 35 mgd. By designing the WWTP for at least 35 mgd, the intent and the practice has been to treat significant stormwater volume that exceeds the average dry weather flow.

Because of the intermingled combined sewers with the over/under construction (see Figure 3-5, as well as an enlarged version in Attachment A), the entire collection system operates as a “de-facto” combined system. Lakewood has nine permitted combined sewer overflows (CSOs); three of which discharge into Rocky River, and the remainder discharge into Lake Erie. The field investigations to develop the Existing Conditions Model found 57 additional overflows within the system.



Figure 3-5: Map of Combined (Purple) and Separate (Green) Sewers

Table 3-1 lists the originally identified 66 CSOs and their locations. Three overflows have been eliminated and are noted as such in Table 3-1. The table also notes the nine permitted CSOs. The overflow name is a combination of the receiving water and the Model's outfall designation:

- LEWS – Lake Erie watershed
- RRES – Rocky River east side
- RRWS – Rocky River west side

In addition to the location, Table 3-1 list the Model overflow manhole number, the type of overflow structure and the depth at which overflows begin:

- Raised pipe – the overflow pipe is higher in the manhole and the water level must rise to the specified height before an overflow begins
- Leaping weir – dry weather flow drops down through a hole in the bottom of the manhole to a smaller dry weather pipe. A portion of wet weather flow stays in the pipe and travels to the receiving waters. Instead of an overflow depth, the size of the opening is listed.
- Weir – a wall in the manhole directs dry weather flow to the dry weather pipe. In wet weather, an overflow occurs when the depth rises above the specified value.

**Table 3-1: Lakewood CSOs**

Overflow Name	Location	Model ID	CSO Configuration	Depth to Overflow (feet)	Notes
LEWS1035	Edgewater 420' east of Nicholson	059C001	Weir	4.67	CSO-059
LEWS1035-A	Thoreau & Clifton	059T014	leaping weir	11"x12"	
LEWS1040-A	North end of Nicholson	059BS852	Weir	7.7	
LEWS1040-B	Clarence at Detroit Avenue	059AC1310	raised outlet	2	
LEWS1040-C	Grace & Detroit Avenue	059AT897	leaping weir	8" Ø	
LEWS1040-D	Detroit Avenue 270' east of Elbur	059AS050	raised outlet	4	
LEWS1040-E	Detroit Avenue at Elbur	059AS047	raised outlet	4.1	
LEWS1040-F	Wyandotte & Detroit	059AC046A	Weir	0.5	
LEWS1040-G	Madison Avenue at Lewis	059S078A	raised outlet	0.7	
LEWS1040-H	Madison Avenue at Elbur	059C0076A	Weir	2.55	
LEWS1045-A	North end of Wilbert	059BS012A	Weir	0.58	
LEWS1055-A	Edgewater 340' east of Homewood	059BC006	raised outlet	0.1	
LEWS1055-B	Clifton 220' east of Jackson	057S037			eliminated
LEWS1055-C	Detroit Avenue at Parkwood	059AS045	raised outlet	7.2	
LEWS1055-D	Detroit Avenue at Robinwood	059AC036	raised outlet	0.24	
LEWS1055-E	Cedarwood & Blossom Park	059AC1036	Weir	0.6	
LEWS1070-A	North end of Homewood	002S769	raised outlet	0.67	
LEWS1070-B	Whippoorwill & Clifton	057C023	raised outlet	0.25	
LEWS1110	Edgewater 260' east of Roy	058C001A	Weir	0.6	CSO-058
LEWS1130-C	SE corner of Belle & Clifton	057C012A	Weir	1	
LEWS1135	460' north of Lake & Belle	057T001	raised outlet	2	CSO-057
LEWS1150	Edgewater 140' east of Leedale	056C490	Weir	1.1	CSO-056
LEWS1150-A	Edgewater at Rosalie	056C1301	Weir	0.8	
LEWS1150-B	Andrews at Clifton Blvd.	056S020	Orifice	2	
LEWS1150-C	Detroit Avenue at Elmwood	056C289	raised outlet	1	
LEWS1150-D	Detroit Avenue at Mars	056C295	raised outlet	2	
LEWS1150-E	Hilliard and Victoria	056T061	leaping weir	3"x3"	
LEWS1155	Edgewater 130' east of Leedale	056C915	weir	0.8	
LEWS1180-A	Clifton and Lakeland	002S188	weir	5.4	
LEWS1195-A	Summit at Edgewater Drive	002C244	raised outlet	11.3	
LEWS1195-B	Clifton Blvd. at Brockley	002S184			eliminated
LEWS1210-A	North end of Forest Cliff Drive	002S242	weir	2	
LEWS1215-A	Erie Cliff 350' north of Lake	002C240A	weir	0.7	
LEWS1220-A	North end of Maple Cliff	002C238A	weir	0.33	
LEWS1225	Edgewater 270' west of Maple Cliff	055C003	weir	0.6	CSO-055
LEWS1285-A	Edgewater 980' east of Webb	002C232	weir	0.8	
LEWS1285-B	Lake Ave 925' east of Webb	002T207	leaping weir	0	
LEWS1285-C	Edwards & Clifton	002C178	raised outlet	10.2	
LEWS1295	Webb and Lake	002C197	weir	0.5	
RRES1140	Scenic 110' south of Detroit	053C009	weir	2.05	CSO-054

**Table 3-1: Lakewood CSOs**

Overflow Name	Location	Model ID	CSO Configuration	Depth to Overflow (feet)	Notes
RRES1145-A	West Clifton 70' south of Detroit	002S1401	weir	0.82	
RRES1145-B	West Clifton 260' south of Detroit	002S1420			eliminated
RRES1145-C	West Clifton 600' south of Detroit	002S1415	weir	1.02	
RRES1145-D	West Clifton 910' south of Detroit	002S1418	weir	0.6	
RRES1145-E	West Clifton 80' south of Detroit	002S4416	weir	0.66	
RRES1145-F	West Clifton 280' south of Detroit	002S4414	weir	0.8	
RRES1145-G	West Clifton 620' south of Detroit	002S4412	weir	1.05	
RRES1145-H	West Clifton 930' south of Detroit	002S1409	weir	0.86	
RRES1145-I	Detroit Avenue at Clifton Place	002C026A	raised outlet	1.5	
RRES1145-J	Detroit Avenue at Rockway	002C029A	raised outlet	4.4	
RRES1145-K	Spring Garden & Detroit	002C4392	raised outlet	1.5	
RRES1145-L	Detroit Avenue at Larchmont	002C032A	raised outlet	1.1	
RRES1145-M	Detroit Avenue at Wagar	002C039A	raised outlet	0.7	
RRES1145-N	West Clifton at railroad tracks	002S253	weir	23.5	
RRES1145-O	West Clifton 60' south of RR tracks	002S252	weir	0.6	
RRES1145-P	West Clifton 110' south of RR tracks	002S1405	weir	0.6	
RRES1145-R	West Clifton 480' south of Baldwin	002S4064	weir	1.2	
RRES1145-S	West Clifton 660' south of Baldwin	002S4062	weir	1.2	
RRES1145-T	West Clifton 130' south of Clifton	002S265	weir	1.2	
RRES1145-U	West Clifton 360' south of Clifton	002S4068	weir	1.2	
RRES1145-V	West Clifton 620' south of Clifton	002S4066	weir	1.2	
RRES1145-W	West Clifton and Clifton	002S264	weir	3.6	
RRES1160-A	Olive at Hilliard Road	052SMeter006	leaping weir	0.3	
RRES1165-S	Riverside & Madison	052S005	raised outlet	7.6	CSO-052
RRWS 1200	Valley @ WWTP	053C002	raised outlet	1.4	CSO-053
WWTP	East end of aerial sewer	CSO-002	orifice	8	CSO-002



3.4 HYDRAULIC CHARACTERIZATION

The model of Lakewood's collection system was created and is continuously updated as new information about complexities within the system arises. There was much unknown about Lakewood's sewers and networks. Field information was used to build, calibrate and analyze the model used to evaluate performance of the system.

A technical memorandum on the calibration of the model was submitted to Ohio and U.S. EPA in 2014. The goal of the model was for the city to better understand the complexities of its sewer collection system. The model is the primary tool used to evaluate the hydrologic and hydraulic performance of various control alternatives in Lakewood's Integrated Planning analysis.

Lakewood's collection system model uses the computer program Storm Water Management Model (SWMM) to calculate the hydraulic dynamics of the collection system in dry and wet weather events. This program is sponsored and supported by U.S. EPA. The Lakewood model has 3,732 pipe segments (totaling 920,000 linear feet of sewer pipe) and 3,646 manholes to represent the collection system. Every effort was made to model all the pipes in the collection system. The map titled Existing Collection System shows the modeled pipes – it is located in Attachment A.

The model was calibrated using flow data from 50 flow monitors and three rain gauges. The monitors collected flow data. The rain gauges collected rainfall in 5-minute intervals. The rainfall data was input into the model, and the program calculated runoff. The model's input parameters were then calibrated to enable the model's calculated flows to match the metered flows.

3.4.1 MODELING A SINGLE EVENT

SWMM is a powerful tool for sewer system analysis. The results can provide insight into complicated hydraulics and can identify potentially unknown or hidden problems within the system.

Prior to modeling wet weather events, a dry-weather flow (DWF) analysis was executed. The purpose of DWF analysis is to characterize the sewer systems behavior without the added influence of precipitation. The analysis of DWF is the basis for model calibration. DWF calibration was evaluated using the Chartered Institution of Water and Environmental Management (CIWEM), formerly the Wastewater Planning and Users Group (WaPUG), calibration parameters for each of the flow meters. Figure 3-6 is an example of DWF calibration results. The heavy black curve is the flow monitor's measured data. The model generated flows are shown in red. Diurnal flow patterns are evident (low flow in the middle of the night, higher flow in the morning and evening). Attachment B has a more detailed explanation of the calibration efforts.

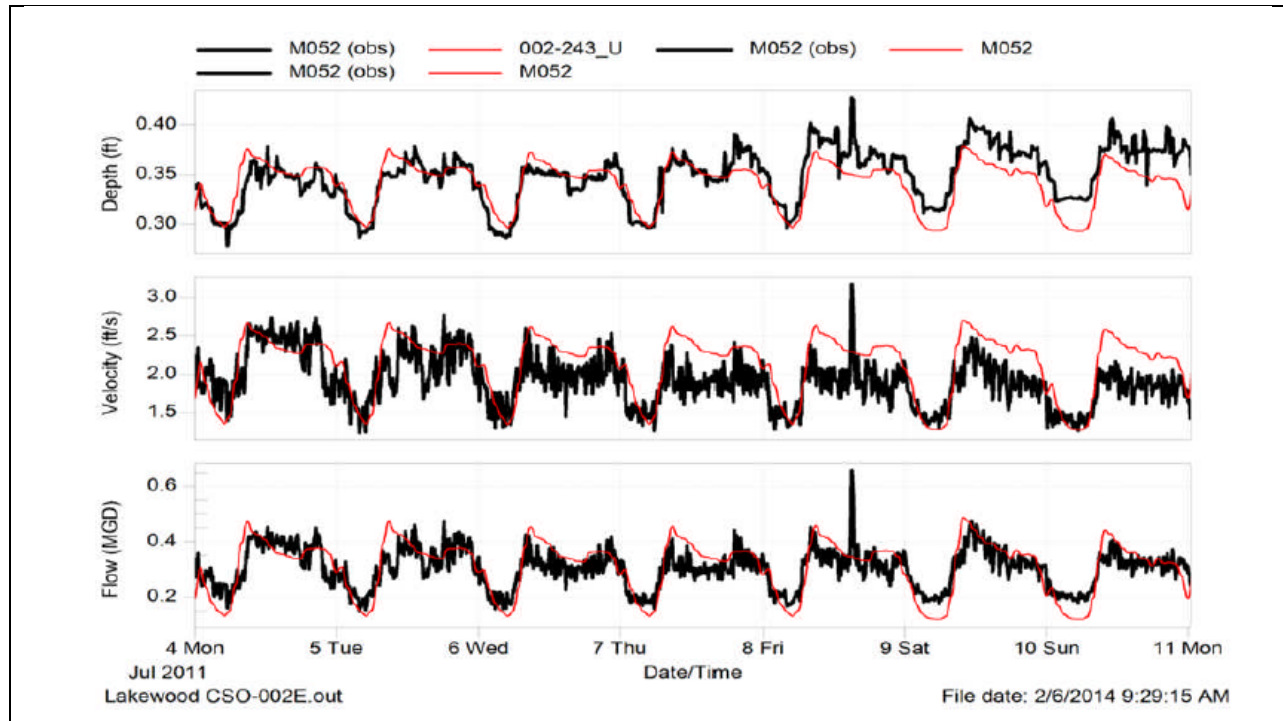


Figure 3-6: Example of Dry Weather Flow Calibration Results

The purpose of wet weather flow (WWF) analysis is to characterize the sewer system's response under the influence of precipitation. The U.S. EPA's Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox is the primary tool used to classify the WWF response. WWF input parameters were added to the Model from the information obtained from SSOAP.

WWF calibration was challenging due to several meters not recording quality data. When data was not of sufficient quality to include in the calibration, the subwatershed was calibrated to the next downstream meter. Figure 3-7 shows an example of single event WWF calibration results. The flow monitor measured data is in black. Model generated flows are shown in red. Chapter 6 of Attachment B details WWF calibration efforts.

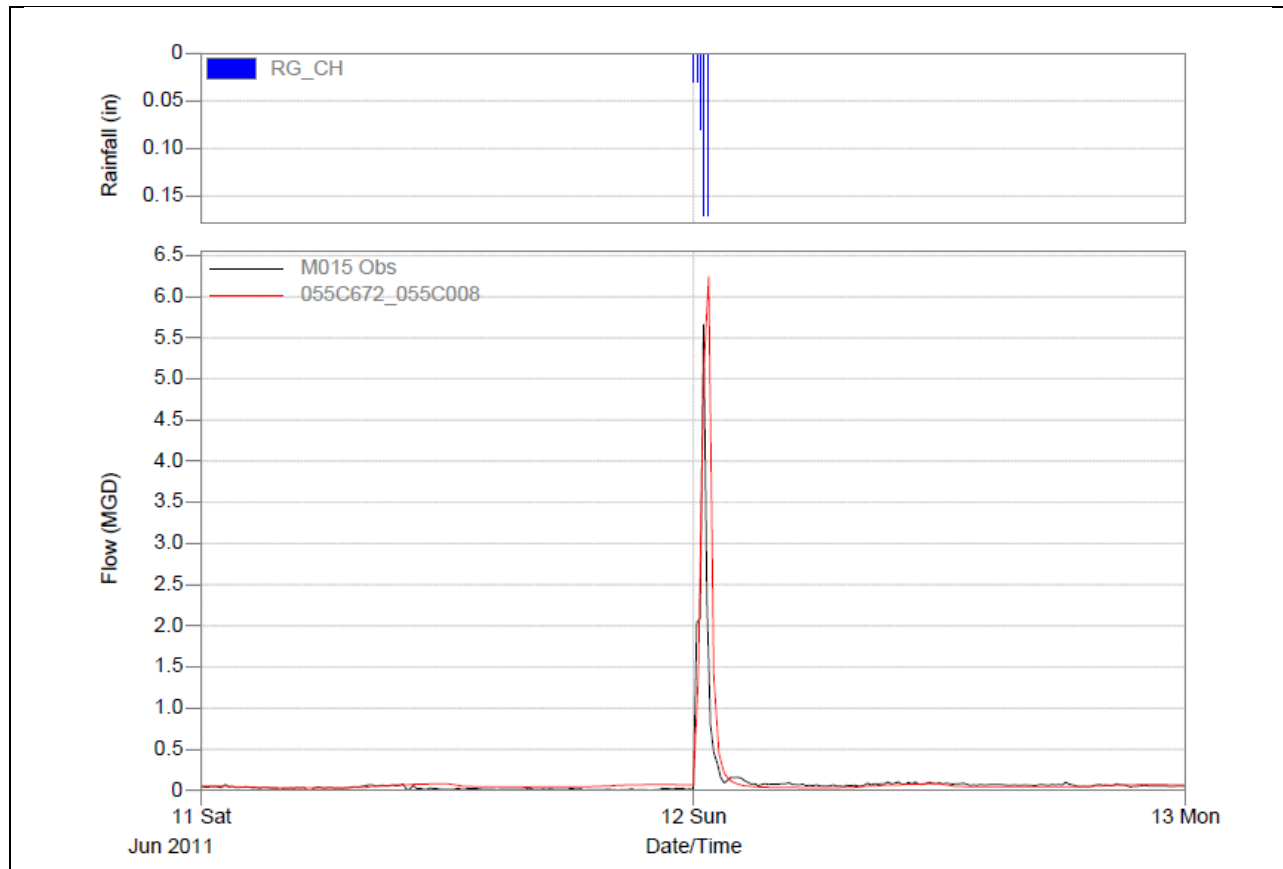


Figure 3-7: Example of Wet Weather Flow Calibration Results

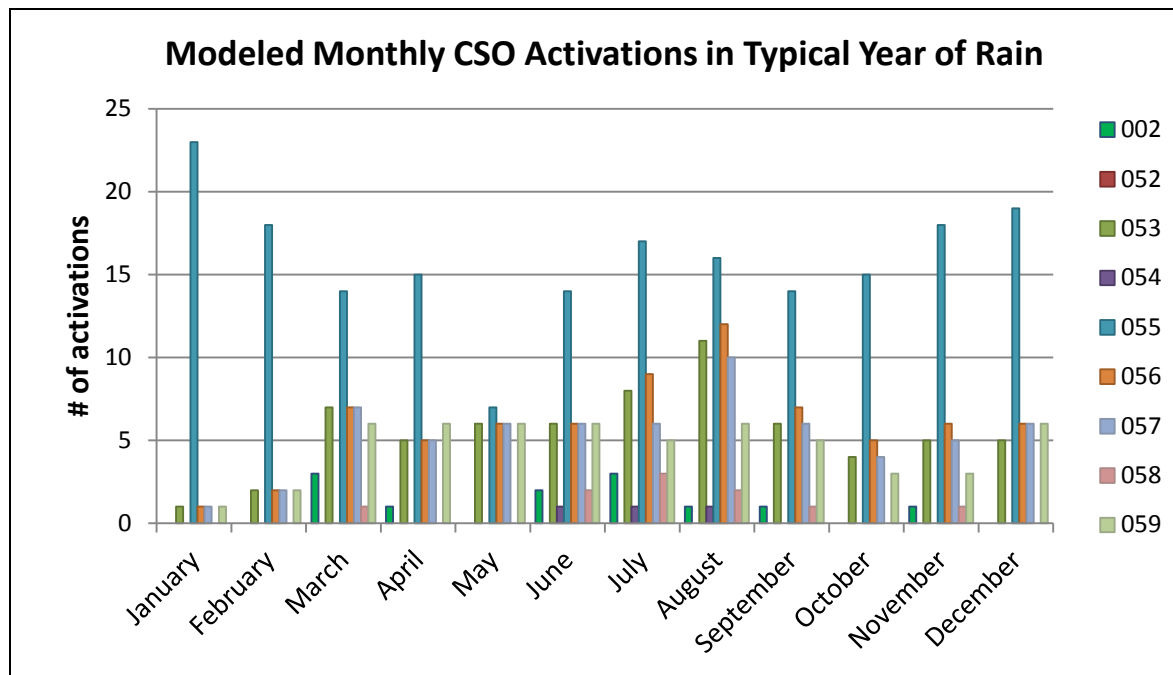
3.4.2 CONTINUOUS SIMULATION MODEL

The purpose of continuous simulation modeling is to characterize the sewer's response and recovery to a series of precipitation events. Chapter 8 of Attachment B has further detail on continuous simulation modeling for Lakewood's sewer system.

The first continuous model developed for Lakewood was used to simulate the flow monitoring period (April 2011 to August 2011). After the continuous model was calibrated to the flow monitoring period, the typical year precipitation record was simulated in the calibrated model to determine the number of overflow activations and volume discharged during typical precipitation conditions (Table 3-2 and Figure 3-8). The model showed that CSO-055 is the most active. This is likely due to the configuration of the overflow—once the depth in the 30-inch sewer exceeds 7 inches, an overflow is recorded. August has the greatest number of activations overall due to increased rain intensity during that time of year. Long-term metering, which is currently taking place, and calibration to the new meter data will provide more confidence in the modeling.



Table 3-2: Estimated CSO Activations and Volumes in a Typical Year of Rain									
CSO	002	052	053	054	055	056	057	058	059
January	0	0	1	0	23	1	1	0	1
February	0	0	2	0	18	2	2	0	2
March	3	0	7	0	14	7	7	1	6
April	1	0	5	0	15	5	5	0	6
May	0	0	6	0	7	6	6	0	6
June	2	0	6	1	14	6	6	2	6
July	3	0	8	1	17	9	6	3	5
August	1	0	11	1	16	12	10	2	6
September	1	0	6	0	14	7	6	1	5
October	0	0	4	0	15	5	4	0	3
November	1	0	5	0	18	6	5	1	3
December	0	0	5	0	19	6	6	0	6
Sum	12	0	66	3	190	72	64	10	55
Volume (MG)	3.16	0	0.09	3.53	0.59	36.48	2.17	2.23	35.75

**Figure 3-8: Modeled Monthly CSO Activations**



3.5 POLLUTANT MODEL

Lakewood's NPDES permit requires "*adequate characterization*" of the sewer system to allow for "*volume and frequency of sewage discharges as well as pollutant concentrations/loads discharged.*" The hydraulic volume and frequency of sewage discharges are summarized in Section 3.4 and more fully described in Attachment B, *Hydraulic Model Technical Memorandum*. Pollutant characterization was done by modeling pollutants as an enhancement to the Lakewood model. The objective of modeling pollutants is to characterize their concentrations in:

1. Untreated Overflows
2. WWTP influent on dry and wet days

This characterization provides data on overflow pollutant concentrations which can be multiplied by the model's discharge volumes to calculate pollutant loadings. These loadings will enable comparison of long term control alternatives to provide the most cost-effective improvement to the water quality of Lake Erie.

Pollutants added to the model include total suspended solids (TSS), carbonaceous biological oxygen demand (CBOD), total phosphorous (TP), and *Escherichia coli* (*E. coli*) bacteria. Typical concentrations in sewage of the first three pollutants were calculated from five years of WWTP Discharge Monitoring Reports. Pollutants in stormwater runoff were modeled using the program's available buildup and washoff equations. The pollutant equations were calibrated with data from five samplers that had attached flow meters. The pollutant model is summarized in this section and more fully described in Attachment C, *Pollutant Model Technical Memorandum*.

3.5.1 LAND USE CATEGORIES

Pollutants in stormwater runoff will vary depending on the land's usage. Five categories of land usage characterize runoff pollution in the Lakewood model. The Cuyahoga County Auditor's database provided acreages of parcels with the below usages. The following land usage categories (percentages are the amount of Lakewood's land with that category) are as follows:

1. 20% - Low-Density Residential – Single and two-family residential properties with land area greater than ¼ acre in size.
2. 60% - Medium-Density Residential – Single and two-family residential properties with land area less than ¼ acre in size.
3. 5% - High-Density Residential – Properties classified as apartments.
4. 10% - Commercial/Industrial – Properties with large impervious areas. In addition to commercial and industrial properties, this group also includes properties listed as institutional (municipal, schools and churches), highway, and active recreation areas.
5. 5% - Open Space – This group includes utility corridors and passive recreation areas.



3.5.2 POLLUTANTS WITHIN STORMWATER RUNOFF

Flow meters and stormwater samplers were used to measure the runoff rates and pollutant concentrations in the storm sewers from the first four land usage categories. Note, the “Open Space” category did not have sewers where sampling could be conducted. Pollutant washoff loadings were calculated from the flow data and pollutant analysis of the stormwater samples. Buildup and washoff equations were chosen from the computer program’s available options. The parameters in the buildup and washoff equations were adjusted to calibrate the model’s washoff pollutant loadings to match the measured pollutant loadings.

Figure 3-9 is an example of one pollutant calibration graph. This is a graph of total phosphorous loadings from surface runoff as washed off during the rain event on September 11, 2015. The blue bars coming down from the top are the measured rainfall every five minutes during the storm. The red squares represent the measured loadings as calculated from the flow meter/sampler data (samples were collected every 15 minutes once the water depth rose more than one inch). The purple line is the 15-minute pollutant loading as calculated from the Model’s calibrated hydraulic flow rates and pollutant concentrations. The shape of this pollutant loading graph and the measured loadings shows that most of the surface pollution is washed off quickly (less than 1½ hours into this storm). This phenomenon (commonly called a “first flush”) was exhibited at most calibration sites.

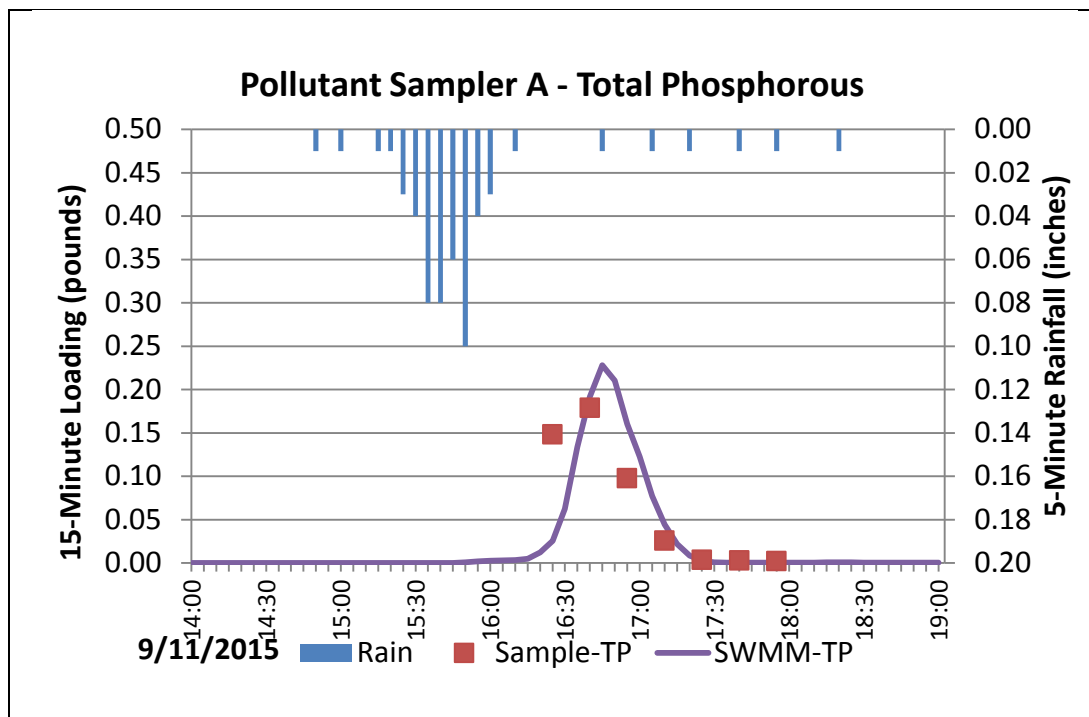


Figure 3-9: Pollutant Calibration Graph Showing First Flush



3.6 TYPICAL YEAR RESULTS

One way to check the calibrated pollutant model was to compare its typical year results to the Lakewood WWTP influent flow quantities. Table 3-3 shows this comparison. The 4-year Discharge Monitoring Report (DMR) Influent values are based on the average yearly WWTP influent flow and loadings as calculated from DMR data for 2010 to 2014 (2011 was excluded as an outlier because it had over 60 inches of rainfall). The model's typical year values are slightly higher due to the higher total rainfall. *E. coli* loadings are not shown in Table 3-3 because there are no measured influent concentrations in the DMR data.

Table 3-3: Model vs. WWTP DMR Influent Flows and Loadings					
	Total Rainfall (inches)	Flow (MG)	CBOD (lbs.)	TP (lbs.)	TSS (lbs.)
Model Typical-year Influent	37.52	2,787	1,843,662	70,000	2,747,213
4-yr DMR Influent	34.15	2,635	1,760,037	66,960	2,613,710
Model to DMR Ratio	110%	106%	105%	105%	105%

After setting up and calibrating the model parameters to calculate pollutant loadings, the program was run with a typical year of rainfall. Output from the typical year analysis serves as the basis for calculating pollutant reductions of future improvements. The Table 3-4 shows the amount of flow and pollutants in a typical year currently treated by the Lakewood WWTP (excluding the portion of flow that goes to Northeast Ohio Regional Sewer District) and the amount of untreated flow discharged through the city's outfalls. In addition to the total flows treated and discharged, the Table 3-4 also shows the percentages of flow and pollutants captured for treatment by the collection system during wet weather events on a system-wide annual average.

Table 3-4: Modeled Typical Year Flow and Pollutant Loadings					
	Flow (MG)	CBOD (lbs.)	<i>E. coli</i> (cfu)	TP (lbs.)	TSS (lbs.)
Model Influent	2,787	1,843,662	2.06E+18	70,000	2,747,213
To NEORSD	398	27,142	3.04E+16	1,030	40,469
Total Quantity Treated	3,185	1,870,804	2.09E+18	71,030	2,787,682
Lakewood Outfalls	577	30,720	2.30E+16	1,129	56,356
Percentage of Total Flow Captured for Treatment	83.2%	98.2%	98.8%	98.3%	97.8%
Percentage of Wet Weather Flow Captured for Treatment	73.1%	94.3%	96.0%	94.4%	93.2%



CHAPTER 4 – PUBLIC PARTICIPATION

4.1 SUMMARY OF SECTION

Maintaining meaningful communication with stakeholders and the public was of utmost importance in the development of this plan. Lakewood established a stakeholder involvement process which involved publicizing the group, asking for volunteers, having monthly public meetings, and using the public's preferences to shape the plan. Lakewood's efforts were in concert with and fulfillment of Elements 3 and 4 of EPA's Integrated Planning Framework.

4.2 GOALS

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

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 funding and implementation are more likely to follow.

The city's public input goals were as follows:

1. Help educate and engage the public on Lakewood's storm and sanitary sewer infrastructure
2. Help educate and engage the public on overflows
3. Help educate and engage the public on green and grey infrastructure options
4. Obtain suggestions from public for how Lakewood might reduce its overflows

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 IWWIP; solicit public preferences; maintain positive working relationship with public; gather support for its implementation

4.3 BALANCING PUBLIC OUTREACH AND TECHNICAL ANALYSIS

While the plan must be based on science (such as: hydrology, water quality, and hydraulics) if technical analysis is completed in isolation of stakeholder understanding the plan is less likely to be brought to fruition. Accommodating smart growth and development in



a very developed community like Lakewood (~70 percent impervious) is a balancing act involving planning, engineering, and public input in decision making.

Achieving integration of the engineering, planning, and ecological perspectives was initiated via strong communication alongside data collection, modeling, and analysis. The results of the models were used in working sessions with the stakeholders so the public can use it to aid in decision making. Maintaining the effective communication between the various public and municipal participants will directly impact long-term planning and success of wet weather controls.

4.4 LAUNCHING “CLEAN WATER LAKEWOOD: REBUILDING THE PIPELINE TO OUR FUTURE”

The public participation discussion began in March 2015 by asking the Mayor’s office and the Department of Public Works: how can Lakewood obtain valuable input on CSO control strategies from the public?

In order to gain valuable input Lakewood needed a public that understands the intricacies of the problem. To that end, Lakewood launched “Clean Water Lakewood: Rebuilding the Pipeline for Our Future” (hereafter referred to as CWL). A logo (Figure 4-1) 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 who would dedicate themselves to a task force requiring monthly meetings and discussion on how Lakewood can improve its water infrastructure and reduce pollution going into Lake Erie and Rocky River (news articles compiled in Attachment H).



Figure 4-1: Clean Water Lakewood’s Logo



Twenty-five people showed interest. Due to schedule conflicts or other reasons, approximately 18 people ended up committing themselves to monthly meetings. CWL meetings were scheduled from 7-9PM on the 3rd Tuesday of every month starting in July of 2015.

Backgrounds of citizen 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 the Lakewood citizen volunteers, a number of city of Lakewood employees were also attending the meetings, including representatives from the following departments: Mayor's Office, Department of Public Works, the Building and Planning Department, and City Council.

One goal the city had for the CWL taskforce was to start public participation early in Phase 1 of the NPDES permit, and continue it indefinitely. In Phase 1, the city started educating the public on CSOs and the possible solutions. This public engagement will continue into the detailed development of Phase 2 of the IWWIP.

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

Each meeting had a separate topic, as noted in Table 4-1. The first six monthly meetings were targeted as education meetings, and then starting in December, participants broke into four smaller groups, each focusing on a different street or neighborhood in Lakewood, including: Larchmont Ave., Lake Ave., Birdtown, and Parkwood Ave.

Reasoning behind choosing each of these study areas is as follows:

1. Larchmont Ave. 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 Ave. 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 Ave. and Clifton Blvd.
3. Parkwood Road has an over/under sewer that discharges to a sanitary sewer on Detroit Ave. Sanitary sewer on Detroit Ave was constructed in 2007 but regularly overflows into storm sewer on Detroit Ave. This overflow is similar to 7 other overflow locations in Lakewood.
4. Birdtown has 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 Ave. This



neighborhood used to be a company town for Union Carbide and has been the focus of specific planning initiatives by Lakewood.

These four 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 group members 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 groups brainstormed and came up with very thoughtful and creative solutions. Summaries of the modeling suggestions were emailed to the group members to ensure what they asked for were 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.

**Table 4-1: 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 physically see and 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 –per-group 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, evaluating successful versus unsuccessful alternatives
Modeling results for Larchmont Ave.	
Modeling 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



4.5 MEETING SUMMARIES

Below and on the following pages are a set of one-page documents, reflecting key topics in each public meeting. The completed handouts are in Attachment H.

Meeting Date: July 15, 2015, **Number of people in attendance:** 20

Meeting Topic: Introduction & Overview

Goal: To give an overview of the challenges Lakewood faces in regards to overflows

Summary

- Lakewood faces regulatory requirements that involve a variety of infrastructure, policy, and land management solutions. Clean Water Lakewood will help to evaluate various water infrastructure improvement alternatives based on the working group's suggestions, reflecting the community's criteria and values.
- Combined sewer overflows
 - During dry weather, sewer transports all of the wastewater to a sewage treatment plant, where it is treated and then discharged to a water body.
 - During periods of heavy precipitation the wastewater volume can exceed the capacity of the sewer system or treatment plant. For this reason, sewer system is designed to overflow and discharge excess wastewater directly to waterways.
- CSOs are a major water pollution concern for approximately 772 cities in the U.S. that have combined sewer systems (EPA, 2014).
- With the passage of the Clean Water Act in 1972, such overflows and other discharges must be controlled to make water fishable and swimmable, among other uses.
- US EPA and Ohio EPA have mandated that Lakewood capture, treat or remove the millions of gallons of overflow that happen every year.
- As with the original investments in the city, Lakewood must invest in its infrastructure so that it meets the demands of Lakewood's second century, and for the benefit of human and environmental health.
- Introductions around the room. People stated why they were interested in joining Clean Water Lakewood and a bit about their background.
- Explained our meeting structure and discussion expectations: mostly about being respectful.
- Listed communications they can expect from us, including media monitoring emails regarding stormwater and CSOs.
- List of common acronyms and definitions provided.
- All members given a 3-ring binder with background info, and each subsequent handout is meant to be added to binder.



Meeting Date: August 11, 2015, **Number of people in attendance:** 18

Meeting Topic: Tour of Lakewood's Waste Water Treatment Plant (WWTP) and Nearby Overflow Site

Goal: To learn how a sewage treatment plant works, and to gain an understanding of where the overflows discharge when it rains.

Summary

- Tour led by Bill Crute, the Division Manager. Plant treats an average of 7.85 million gallons of sewage water a day, and consistently meets all state water discharge permits.
- Overall the cost to collect all of the waste water and manage the sewer system is estimated to cost \$6.7 million in 2015. The cost to run the waste water treatment plant is estimated at \$4.5 million for 2015.
- In Lakewood, we have more than 875,000 feet (166 miles) of pipe, which includes 393,500 feet of sanitary sewer, 133,500 feet of combined sewer and the rest is storm.
- Rainfall and stormwater can overwhelm the sewers and dramatically increase the volume reaching the plants, leading to overflows.
- A map of the plant was provided. We reviewed: headworks, grit removal chambers, primary clarifying, secondary treatment, UV disinfection, and sludge processing.
- Reviewed information on CSOs and volume of overflows Lakewood has in a typical year. Included maps of the 55 outflow pipes leading to the lake or river from Lakewood, and 2) CSO sewersheds of Lakewood. Some overflow pipes were visible from the treatment plant, and those were discussed.
- Lakewood West End CSO Elimination Project is removing two permitted CSOs that discharge into Rocky River: RRES 1140 (CSO-054) and RRWS 1200 (CSO-053). By November of 2016, there will be a new pipe spanning across the river and leading into the sewage treatment plant to treat this combined flow.
- Defined gray infrastructure as referring to man-made, constructed assets, like tunnels and storm drains. Various types of gray infrastructure were included as graphics with basic descriptions in the handout:
 - o Storage tunnels
 - o Sewer separation
 - o High rate treatment



Meeting Date: August 26, 2015, **Number of people in attendance:** 19

Meeting Topic: Tour of Watershed Stewardship Center at West Creek Reservation

Goal: Learning and interacting with the green infrastructure at the Watershed Stewardship Center. We also hope to learn about the effectiveness and maintenance of some of these options.

Summary

- The Watershed Stewardship Center is located in Parma. Center opened in 2013. Jennifer Grieser, focusing on Urban Watersheds for the Cleveland Metroparks, led the tour as well as an overview of results from a local green infrastructure study.
- Education on hydrologic cycle; discussed post-urban and pre-urban hydrographs.
- Impervious surfaces associated with suburban and urban land uses alter the amount of water going into each of the above three pathways. The biggest change is a reduction in the volume of water seeping into the ground, resulting in an increased volume going to our surface water. This has implications for water quality in Lake Erie, affecting habitat for fish and wildlife as well as drinking water for humans.
- Development commonly eliminates natural green areas that once absorbed and filtered stormwater, the result is downstream flooding, erosion, and increases in various types of pollution; including: pet waste, fertilizers, salt, and sediment.
- In Lakewood, about 70 percent of the land area is covered by impervious surfaces including areas devoted to houses, driveways, streets, sidewalks and parking lots, resulting in a significant amount of surface water runoff during storms.
- Parts of Lakewood are serviced by a one-pipe system, carrying both storm water and sanitary waste. During rain events, the pipe capacity is overwhelmed, causing a combination of sewage and storm water to drain into Lake Erie, potentially violating the Clean Water Act and our Ohio EPA discharge permit (NPDES).
- Some solutions to remediate these discharges include green infrastructure, or on-site actions that can be taken to capture rainwater after it has hit the ground but before it flows to the sewer.
- Tables, graphics and definitions were included for the following: permeable pavements, retention basin/stormwater pond, green roof, bioretention, rain garden, rain barrels, infiltration trenches and basins, and filtration. Tables included information on green infrastructure common in urban areas, and green infrastructure processes that main serve to reduce volume.



Meeting Date: September 15, 2015, **Number of people in attendance:** 21

Meeting Topic: Part 1: Clean Water Act Policy Introduction; Part 2: Understanding Source Control on Private Property via Inflow and Infiltration

Goals: 1) to learn about the NPDES permit and why Lakewood has one and 2) to learn how homeowners play a role in reducing the volume of water going into the sanitary sewer unnecessarily.

Summary:

Part 1: CWA overview

- The Clean Water Act (CWA) establishes the structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
- The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained.
- EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges from point sources (pipes). Individual homes that are connected to a municipal system do not need an NPDES permit; however, industrial and municipal pipe discharges must obtain permits if their discharges go directly to surface waters.
- Lakewood is in compliance with their effluent from the wastewater treatment plant (WWTP), but our combined sewage and stormwater overflows need to be reduced.
- Summary of Lakewood's NPDES permit requirement in Part I,C:
 1. Characterize the sewer and stormwater system
 2. Monitor and record all overflows
 3. Create an integrated plan that addresses overflows
 4. Install high rate treatment at the sewage plant to deal with wet weather flows
 5. Analyze alternatives to bring overflows into compliance
 6. Bring overflow discharges into compliance with the Clean Water Act

Part 2: How does an individual's property affect sewer overflows?

- When individuals have roof drains or foundation drains connected to the sanitary sewer line, groundwater and rainwater are adding unnecessary water to the sewer system.
- Additionally, when sewer pipes on the individual's property are cracked, ground water leaches in, adding another source of unnecessary water to the treatment plant's load.
- We estimate that 50 percent or more of inflow and infiltration comes from leaking house laterals and improperly connected roof and foundation drains.
- To test this hypothesis, 102 homes on Atkins and Eldred Avenues were investigated to see if their homes are improperly connected, and if their pipes are cracked and broken. Nearly all of the homes had some broken or improperly connected pipes. The city is paying a contractor to fix these issues. After all the 102 homes are properly connected, flows will be re-measured and compared to pre-construction flows, to determine if a significant reduction has occurred due to correct connections.
- Infiltration, inflow, and the homeowner's role were discussed.
- Infographic depicting sources of infiltration and inflow was provided.



Meeting Date: October 20, 2015, **Number of people in attendance:** 17

Meeting Topic: Comparing Green and Grey Infrastructure

Goal: Understanding the advantages and disadvantages of various infrastructure options for addressing combined sewer overflows.

Summary:

- Definitions of common green and grey infrastructure investments were provided. Terms included were: bioretention, street planters, pervious pavements, sand/infiltration filter, tree planting, downspout disconnection, green roofs, blue roofs, rain harvesting, sewer separation, storage tunnels, source control, high rate treatment, and upgrades to waste water treatment plant.
- The following questions were posed to the group:
 - o What are some advantages of green infrastructure? What about for grey infrastructure?
 - o What are disadvantages of each?
 - o Where do you see risks and uncertainties?
 - o What benefits might come out of green infrastructure that won't show up in the modeling?
 - o How might investing in grey infrastructure meet the needs of Lakewood differently compared to green infrastructure?
 - o What other information do you need to know to help make a decision?
- A table of green and grey infrastructure control strategies was provided to them that had the following information:
 - o Name and photo of control strategy
 - o Relative cost (range in cost from \$-\$\$\$\$, as a relative scale)
 - o Pros and Cons
 - o Life cycle and maintenance (range from 1-4, with 4 being the most labor intensive, a simple relative scale)
- A PowerPoint presentation was given that reviewed branded programs that other communities have created to help reduce combined sewer overflows. Cities discussed include:
 - o Milwaukee
 - o Baltimore
 - o Chicago
 - o Seattle
 - o NYC
 - o Menomonee River Valley
 - o Portland, OR



Meeting Date: November 17, 2015, **Number of people in attendance:** 18

Meeting Topic: Integrated Planning Process and Lakewood's Vision for the Future

Goal: Assign small teams of 4 or 5 individuals to look at a specific area of Lakewood and apply the integrated planning process to determining what they think might work best in terms of green and grey infrastructure.

Summary:

- In 2011, EPA wrote a memo encouraging integrated planning approach to waste and storm water obligations.
- Lakewood citizens just recently went through a community vision process and we are using that as our same vision. Part of Lakewood's vision was "Community Wellness", and specifically, adopting environmental best practices.
- Currently, the city is undertaking data collection to ensure they have identified all of their overflows and measuring flows on all of those sites. Our vision is to reduce all of these overflows to be in compliance with the CSO policy.
- Broke into four breakout groups that were each neighborhoods or streets of Lakewood, specifically:
 - Lake Ave. (between Homewood and Estill)
 - Larchmont Ave. (between Detroit and Madison)
 - Parkwood Ave. (between Detroit and Madison)
 - Birdtown (Madison to the North, Plover to the South, Halstead to the East, Magee to the West)
- Each breakout group brainstormed through the vision, goal, and objective process, including items specific to stormwater management like green and grey infrastructure options.
- Discussion continued with factors to consider when developing a plan for managing CSOs, such as:
 - Community and institutional support for green infrastructure, specifically noting the importance of buy-in from community and local government
 - Realistic ideas for the potential of green infrastructure implementation after understanding the physical factors on the landscape, as well as regulatory and social factors

**Meetings from December-March:**

A total of eight meetings were held, two meetings with each of the breakout groups.

We first met with each breakout group to solicit their modeling preferences and then we met again to review the results of the modeling. All preferences and modeling results were provided to the larger group in the April meeting, and provided further below, as well as in Attachment H.

The breakout group meeting schedule was as follows:

Table 4-2: Breakout Group Meeting Schedule

Breakout Group	Soliciting Modeling Preferences Meeting Date	Reviewing Modeling Results Meeting Date
Larchmont Ave.	December 15	February 16
Lake Ave.	December 16	February 17
Birdtown	January 19	March 15
Parkwood	January 20	March 16

Table 4-3: Summary of Public Preferences

<u>Larchmont, between Detroit and Madison</u> ● permeable pavement on sidewalks and drive-way aprons ● bioretention in tree lawns ● south-end of Larchmont rerouted to Franklin sewers	<u>Lake, between Homewood and Estill</u> ● permeable pavement on sidewalk ● bioretention in tree lawns ● downspout disconnection ● detention basin (now replaced with a storm sewer bypassing a combined sewer)
<u>Birdtown: Madison to the north, Plover to the south, Halstead to the east and Magee to the west</u> ● bioretention on vacant lots, at the school, as bumpouts, in tree lawns, including area west of Birdtown ● green roof garages ● permeable pavement at Madison Park ● sewer separation ● routing flow to NEORSD or a detention basin ● 24" combined relief pipe at pinch point on Madison	<u>Parkwood, between Detroit and Madison</u> ● downspout disconnection ● public and private infiltration and inflow improvements such as relining or replacing laterals and public sewer, new manholes to bypass over/under access plates ● upsizing Detroit Ave. sanitary sewer to 4 ft diameter (currently 1 ft) ● upsizing Detroit and Nicholson sanitary sewer to 4 ft (currently 1 ft)



Meeting Date: April 19, 2016

Number of people in attendance: 25

Meeting Topic: Modeling Results and Discussion

Goal: Review public preferences and report on modeling results

Summary:

- Using the preferences suggested by the breakout groups, models were created for each of the focus areas: Larchmont, Lake, Parkwood, and Birdtown.
- In order to evaluate the green infrastructure ideas brought up by this group, a series of models were developed for comparison purposes. A “typical year” of rain-fall is what was used in this modeling exercise.
- The results produced from this modeling study are not intended to be exact. The results should be used to identify if the suggested approaches are practical and the approximate levels of overflow improvements that might be expected.

Results for each focus area:

Table 4-4: Results for Larchmont Ave. Study Area

Model	*Estimated # of over-flows	*Estimated total volume released in overflow (MG)	†Estimated # of overflows including Detroit sewer at full capacity	†Estimated total volume released in overflow (MG)
Existing conditions	2	0.101	14	0.96
With permeable pavement on sidewalk and driveway aprons	0	0	5	0.281
Bioretention in tree lawns or as bump-outs	2	0.007	4	0.309
Both permeable pavement <u>and</u> bioretention	0	0	4	0.052
Redirecting South end of Larchmont to Franklin	0	0	9	0.520

**The two columns highlighted in purple are only including water coming off of Larchmont Ave.*

†The two columns highlighted in blue account for the sanitary sewer on Detroit Ave. being at full capacity, as it currently is during rain events.

**Table 4-5: Results for Lake Ave. Study Area**

Model	Estimated # of over-flows	Estimated total volume released in overflow (MG)
Existing conditions model	9	2.293 (mostly storm flow)
Existing conditions with storm bypass	2	0.092 (combined flow)
Permeable pavement on sidewalk with under-ground storage, with storm bypass	0	0
Bioretention in tree lawns, with storm bypass	0	0
Both permeable pavement <u>and</u> bioretention, with storm bypass	0	0

Table 4-6: Results for Birdtown Study Area

Model	Estimated # of overflows at 059	Total volume released at 059 during wet weather events (MG)
Existing conditions	61	57.9
Diverting to NEORSD	4	0.8
15 MG detention basin in Gold Coast	4	1.1

Table 4-7: Results for Parkwood Ave. Study Area

Model	Number of Overflow Events	Total Volume of Overflows (MG)
Existing Conditions	64	7.32
Detroit & Nicholson 4 ft. diameter sanitary sewer	0	0

The green infrastructure preferences from Birdtown were tested in the model and did not show results significant enough to become in compliance with CSO policy. Those results were included in the handout and are in Attachment H.

The other Parkwood preferences were modeled but did not show results significant enough to become in compliance with CSO policy. Those results were included in the handout and are in Attachment H.

In sum:

- Larchmont can be brought into compliance with the green infrastructure suggested.
- Lake can be brought into compliance with the creation of a stormwater bypass.



- Overflows in the Parkwood area are brought into compliance with Detroit and Nicholson sewers being upsized to 4 feet in diameter, as well as improvements on the public and private sides such as manhole separation and lateral lining.
- Birdtown overflows can be brought into compliance by diverting to NEORSD's system or by creating a detention basin in Lakewood.

4.6 MEDIA OUTREACH

Lakewood is trying to foster an educated and engaged group of citizens who will help communicate their learning's to the broader community, alongside media outreach the city is publishing on CSOs 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.

For the first three months after CWL taskforce started meeting, emails were sent to all participants and city employees associated with the project that included recent news articles or photos related to stormwater or CSOs. These emails can be found on page in Attachment H.

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

Social media:

Facebook

Twitter

Newspaper:

Cleveland.com

The Lakewood Observer

City's Clean Water Lakewood website:

onelakewood.com/cleanwaterlakewood

The CWL website was updated monthly ensuring that handouts were available for all to see. Additionally, meeting summaries, including a list of attendance, were provided and posted to the website.

All CWL meetings were open to the public. A total of six members from the community, who were not CWL volunteers, attended sporadic meetings and engaged in discussion regarding overflows. General public and CWL volunteers were also encouraged to email or call the Mayor's office or CT Consultants with any questions or concerns.



CHAPTER 5 – RECEIVING WATERS CHARACTERIZATION

5.1 BACKGROUND ON LAKE ERIE AND ROCKY RIVER

Most overland flow in Lakewood flows to Lake Erie, except for the western edge of the city which flows to the Rocky River (Figure 5-1). Lakewood's Combined Sewer Overflows (CSOs) discharge to both Lake Erie and Rocky River waterbodies (Table 3-1). Following are descriptions of each waterbody.

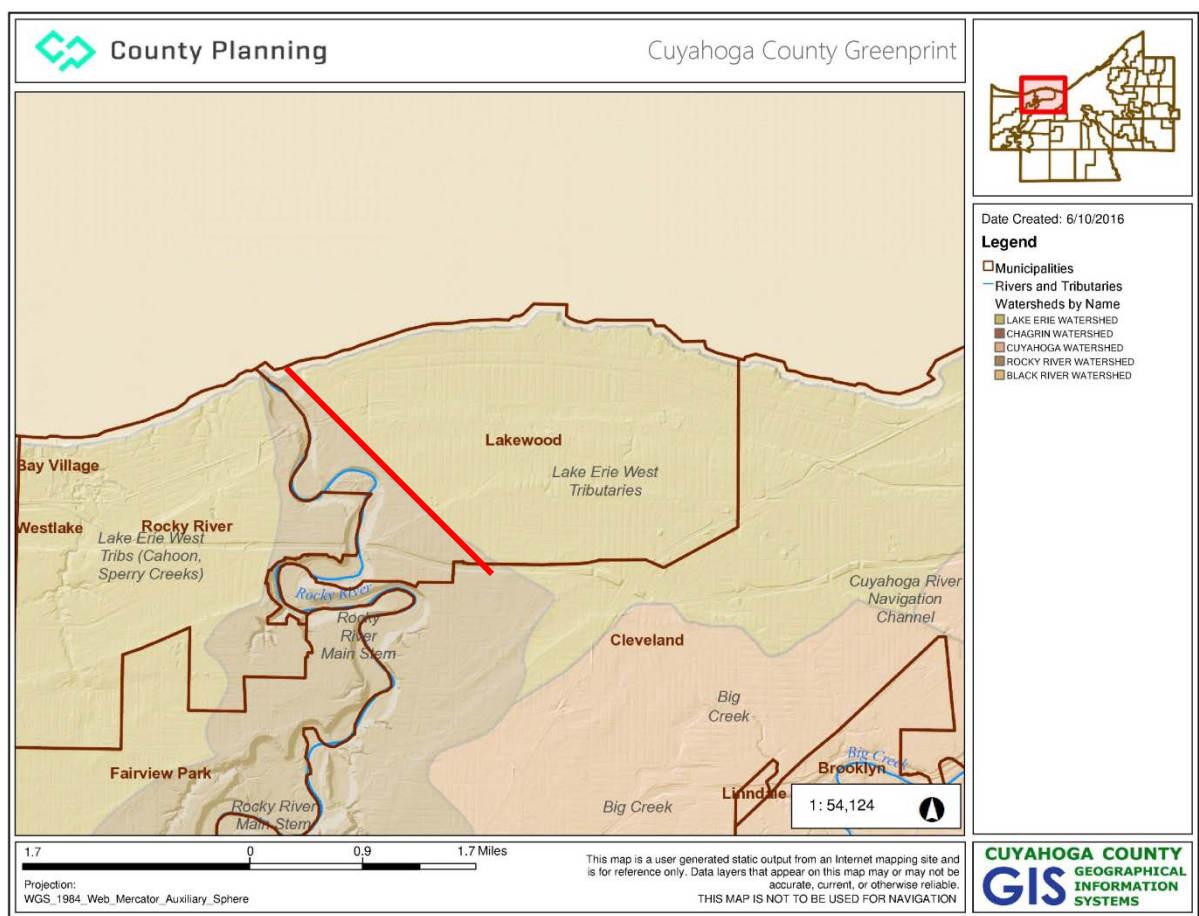


Figure 5-1: Approximate Boundary (Red Line) of Rocky River and Lake Erie Watersheds within the City of Lakewood

5.1.1 LAKE ERIE

The Great Lakes are on the U.S.-Canadian border and make up the largest body of fresh-water on earth. The total area of all the Great Lakes is 95,160 sq. miles, and Lake Erie



makes up 9,910 sq. miles (Figure 5-2). Lake Erie is the furthest south and shallowest of the Great Lakes, with the western basin being the shallowest part of the lake, and the eastern basin the deepest.

A number of rivers are tributary to Lake Erie, the largest being the Detroit River, followed by the Maumee River. Eighty percent of the lake's water flows in from the Detroit River, with only 9 percent coming from all of the remaining watersheds combined. The remaining 11 percent comes from precipitation.

22,720 sq. miles of land drain directly into Lake Erie; however, if the drainage areas of the upper Great Lakes (Superior, Michigan, and Huron) are included, the total drainage area of Lake Erie is 263,650 sq. miles. Lake Erie has a retention/replacement time of 2.6 years, which is the shortest of the Great Lakes.

Lake Erie is the most biologically productive of the Great Lakes, and is referred to as "the Walleye capital of the world." Lake Erie is a popular destination for fishing, swimming, boating, and other recreational activities. A total of 12 million people live in the Lake Erie watershed, including 17 metropolitan areas with 50,000 or more people. Additionally, Lake Erie provides drinking water to more than 11 million of these people.

The Great Lakes were formed through numerous ice-ages. The most recent ice age ended around 14,000 years ago. Over 4,000 years as the glaciers melted they moved north. The receding of the glacier left behind a series of depressions that filled with fresh melt water.

5.1.2 WATER QUALITY CONCERNS FACING LAKE ERIE

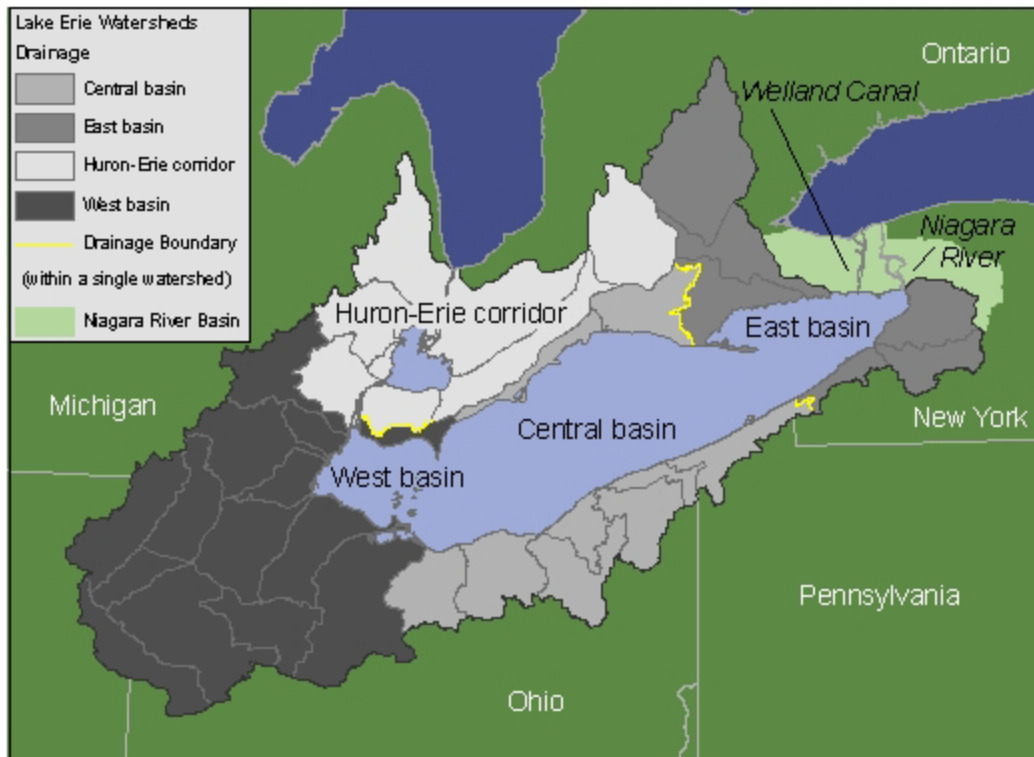
Numerous water quality concerns face Lake Erie, major concerns include: sedimentation, nutrient loading, harmful algal blooms, dead zones, invasive species, climate change, and coastal development. Many of these concerns are inter-related.

Harmful algal blooms (HABs) have gotten the most media attention since the 2014 toxic *Microcystis* outbreak near Toledo. HABs can only happen in warm weather, and since Lake Erie is the shallowest of the Great Lakes, and also the warmest, it is most susceptible to having these blooms. These blooms are triggered when nutrients, specifically phosphorous, are present in the water. Algae have short life spans, when the algae die oxygen is removed from the water through the decomposition process, sometimes this is when toxins are released depending on their species. When oxygen is removed from the water, it is called a "dead zone" as there is not enough oxygen in the bottom water to sustain life.

HABs are common in the western edge of Lake Erie as well as in Sandusky Bay, which is an enclosed bay in the western section of Lake Erie. These blooms have negative impacts on the economy, as well as human and aquatic life. Currently, agriculture is the predomi-



nant source of phosphorous contributing to blooms (Ohio Sea Grant). Phosphorous release from sewage treatment plants has been greatly reduced since the 1970s due to the Clean Water Act.



http://www.glfco.org/lakecom/lec/spatial_inventory/images/LakeErie.jpg

Figure 5-2: Lake Erie and its Drainage Basin

5.1.3 ROCKY RIVER

The Rocky River is a relatively short river that forms most of the western boundaries of the cities of Cleveland and Lakewood, Ohio. This river was ranked by Field & Stream as one of the top steelhead trout rivers in the world.

The Rocky River watershed consists of 664 stream miles and drains approximately 292 square miles in northeast Ohio (Figure 5-3, EPA, 2005 TMDL). The Rocky River is one of the most popular rivers in northeast Ohio, drawing tens of thousands of visitors each year.

The Rocky River watershed includes portions of Cuyahoga, Lorain, Medina, and Summit Counties. The watershed includes 10 tributaries, the main three tributaries include: Abram, Baldwin, and Plum Creeks.



Approximately 59 percent of the watershed is deciduous forest or pasture. Less than 2 percent of the watershed is high density residential. Lakewood is the largest city that the Rocky River passes.

The lower portions of both branches and the mainstem Rocky River flow through a valley, the majority of which is part of the Cleveland Metroparks system, and is heavily forested. Rocky River is generally free from industrial pollution. The mainstem of the Rocky River, where Lakewood discharges, has a drainage surface area of 15.1 square miles, 29 percent of which is impervious surfaces

(<https://maps.cuyahogacounty.us/Html5Viewer/?viewer=greenprint>).

The mouth of the Rocky River, divided between the Cities of Lakewood and Rocky River, has been modified to accommodate a marina. Lakewood represents 2 percent of Rocky River's watershed area.

Eight waste water treatment plants discharge treated effluent to Rocky River or one of its tributaries (Table 5-1). The OEPA Division of Surface Water (DSW) has submitted and received approval for a Bacteria Total Maximum Daily Load (TMDL) for the Rocky River Basin. The lower section of the Rocky River, where Lakewood discharges does not have a TMDL.

Table 5-1: List of WWTPs Discharging to the Rocky River

1. Medina 300
2. Medina 500
3. North Royalton A
4. North Royalton B
5. Strongsville B
6. Strongsville C
7. Plum Creek
8. North Olmstead



myrockyriver.org

Figure 5-3: Rocky River Watershed

5.2 ROCKY RIVER AND LAKE ERIE WATER QUALITY STANDARDS

Rule 3745-1-20 (<http://epa.ohio.gov/portals/35/rules/01-20.pdf>) established the WQS for the Rocky River drainage basin. Rule 3745-1-31 applies to Lake Erie.



Rocky River from river mile 6.4 to the mouth, which includes the City of Lakewood, has the following use designations:

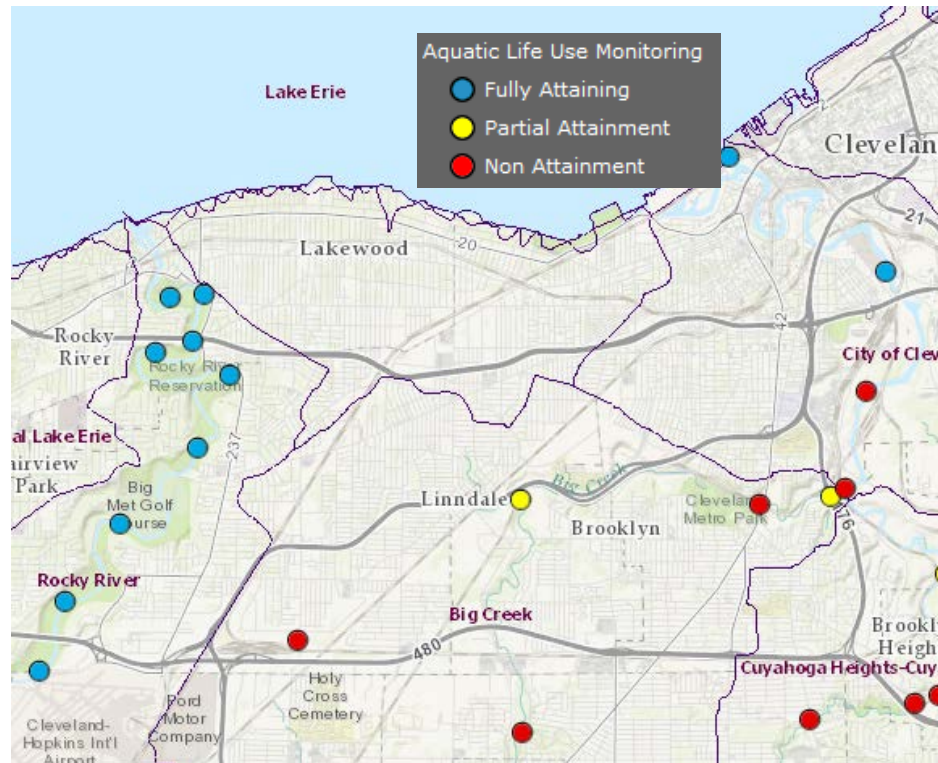
- State resource water
- Warm water habitat
- Seasonal salmonid habitat
- Agricultural water supply
- Industrial water supply
- Primary contact recreation

Lake Erie has the following use designations under OAC 3745-1-31:

- Exceptional warm water habitat
- Superior high quality water
- Public water supply
- Agricultural water supply
- Industrial water supply
- Bathing waters

5.2.1 WATER QUALITY REPORTING

Every two years, Ohio EPA updates a report on the attainment of water quality standards. The report satisfies the Clean Water Act requirements for both Section 305(b) for biennial reports on the condition of the State's waters and Section 303(d) for a prioritized list of impaired waters. The 2016 Integrated Report is the latest approved biennial report. The Ohio EPA website includes an interactive map summarizing the analytical results of its monitoring. The map uses dots to show the locations that have been sampled and colors them to summarize the testing results. A portion of the map, which includes the Rocky River Watershed and parts of Lake Erie, is shown in Figure 5-4.



<http://www.wapp.epa.ohio.gov/gis/mapportal/IR2014.html>

Figure 5-4: OEPA 2016 Integrated Report Showing Aquatic Life Monitoring Results

The blue dots along the main stem and the east and west branches of Rocky River designate those sampled areas as being in full attainment of the river's aquatic life use standards. The aquatic life monitoring measures biological and chemical parameters, including: macroinvertebrate diversity, fish assemblages and water chemistry.

Portions of Abram Creek (not shown in map), which is in the southern portion of the Rocky River Watershed, is the only area of river not in full attainment of the aquatic life use standards.

There is no current Lake Erie shoreline data for the CSO communities of Lakewood and Euclid. The nearest shoreline point is the mouth of the Cuyahoga River, which is also in full attainment of aquatic life use standards.

5.2.2 BACTERIA MONITORING

On a weekly basis the Cuyahoga County Department of Health collects a water sample from Clifton Beach, on the western edge of Lakewood. Northeast Ohio Sewer District collects a daily sample at Edgewater beach, located 1.5 miles east of Lakewood city line.



All of the data is publicly available (<http://publicapps.odh.ohio.gov/BeachGuardPublic/>). The data that was available as of August 23, 2016 has been summarized in the below graphs. Figure 5-5 compares single sample values, whereas Figure 5-6 shows the running geometric mean of *E. coli* levels at both beaches.

As seen in Figure 5-5 and 5-6, there is not a consistent pattern showing increasing bacteria levels in the water after a rain event. Plotting rain vs bacteria returned an $r^2=0.004$, indicating that *E. coli* levels do not vary with rainfall.

Research shows *E. coli* concentrations in the water to be correlated to *E. coli* concentrations in the sand beneath the water (Whitman *et al.*, 2003). While it is known that *E. coli* originates from either human or animal waste, it is also known that during the warmer months *E. coli* can sustain an independent population density. Since the bacteria counts do not seem to consistently be related to rain events, it may be that independent populations in the sand are contributing to the *E. coli* concentrations. No research is available to determine sand *E. coli* populations at these two beaches.

The lack of consistent evidence of rain events (Figure 5-5) may be due to many factors, such as: dilution effect, death of *E. coli*, and the timing of sampling. Additional bacteria sampling may improve our understanding of the relationship between the CSOs and the beach water quality within the Lakewood community.

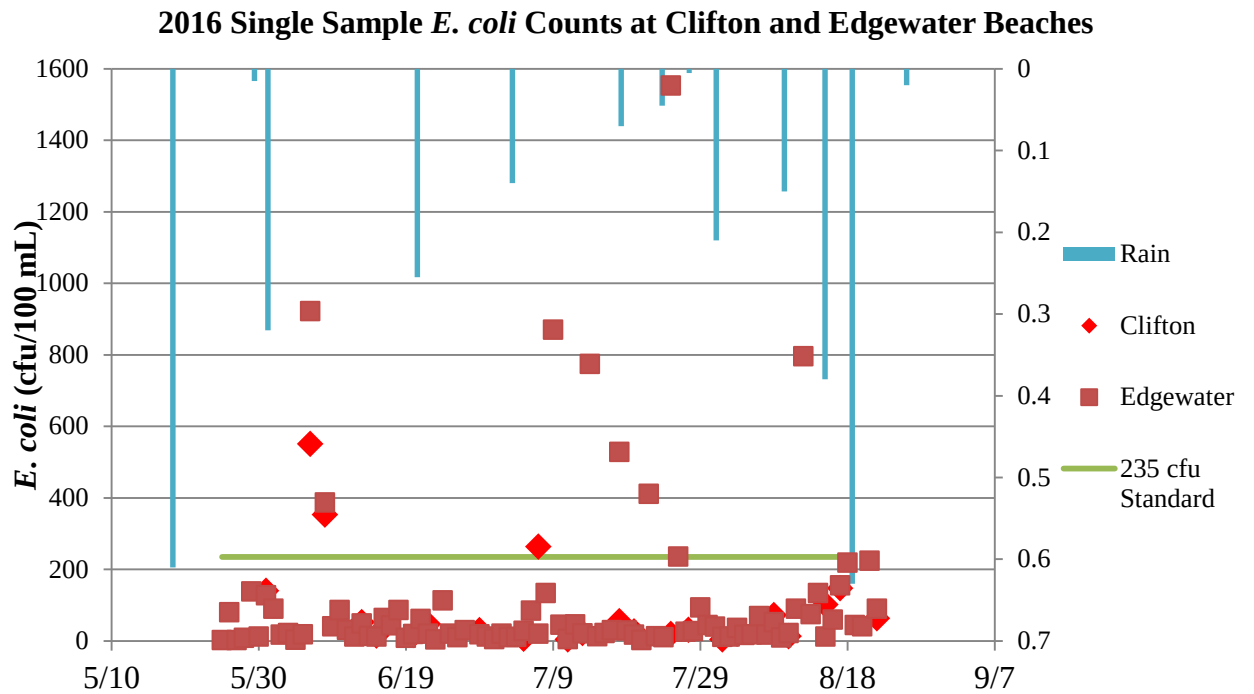


Figure 5-5: *E. coli* sampling Results in 2016 at the Two Beaches in and near Lakewood: Clifton and Edgewater (Note, Clifton Beach is sampled weekly, while Edgewater Beach is sampled daily.)

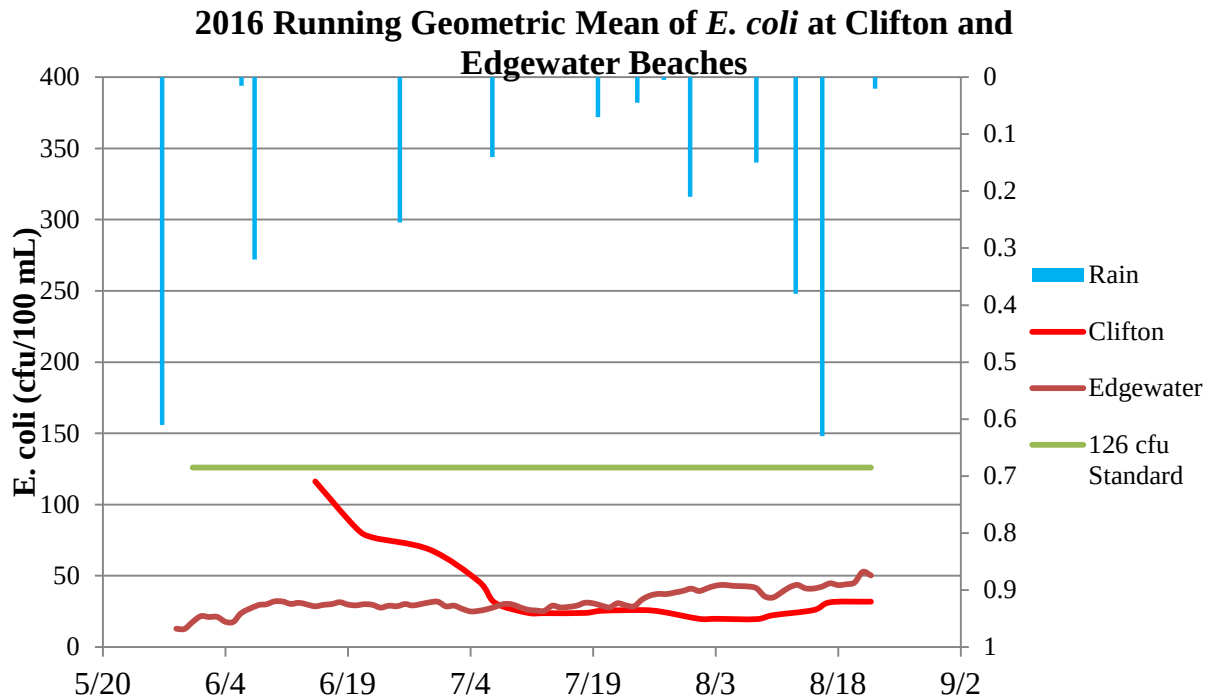


Figure 5-6: Running Geometric Mean *E. coli* Sampling Results in 2016 in and near Lakewood: Clifton and Edgewater (Note, Clifton Beach is sampled weekly, while Edgewater Beach is sampled daily.)

5.3 HISTORIC WATER QUALITY SAMPLING OF CSOs

Under the National Pollutant Discharge Elimination System (NPDES) permit, the WWTP is responsible for submitting results of the CSO monitoring program to OEPA. The city monitors the CSOs on a rotating basis. Each quarter, three CSOs are equipped with flow meters and automatic Sigma 900 samplers equipped with one single bottle for capturing the first flush. The meters and samplers are installed and maintained by Lakewood's collection system maintenance crews. The monitoring program requires sampling and analysis for one CSO event per month for total suspended solids (TSS) and carbonaceous biological oxygen demand (CBOD).

For each CSO that is monitored, a report is generated with the volume of flow discharged and any laboratory analysis of concentrations. Loadings are then calculated by multiplying the flow by the concentration.

The sampling results for 2013-2015 are included in Figure 5-7. Note, outfall 002 is not included in this table, as currently that water quality is equal to the WWTP influent pipe. The Pollutant Model Technical Memorandum has full details on WWTP influent water quality parameters.



Figure 5-7 shows 059 to have the highest concentrations of both TSS and CBOD, while 054 and 058 have the lowest concentrations likely due to their volumes being composed mostly of stormwater and very little sanitary waste. All data shown in Figure

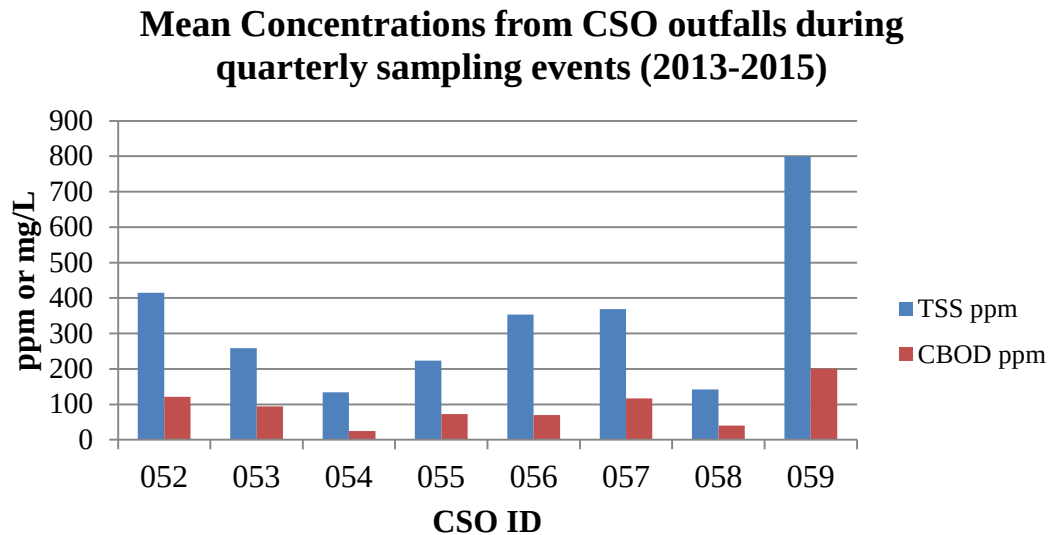


Figure 5-7: Mean Concentrations of TSS and CBOD from CSOs (2013-2015)

In summary, Rocky River is in full attainment of aquatic life use standards. No near shore data is available from the 2016 OEPA Integrated Report to determine shoreline water quality near Lakewood. Lakewood's overflows are consistently monitored and reported to the EPA. Bacteria monitoring at beaches shows inconsistent results relating to wet weather events.

5.4 REFERENCES

Whitman, Richard L., and Meredith B. Nevers. "Foreshore sand as a source of *Escherichia coli* in nearshore water of a Lake Michigan beach." *Applied and Environmental Microbiology* 69.9 (2003): 5555-5562.

Braig, Eugene C., *et al.* "Harmful Algal Blooms in Ohio Waters." Ohio Sea Grant (2011).

<http://www.utoledo.edu/law/academics/ligl/habs-workshops.html>

<http://www.epa.gov/greatlakes/lake-erie>

<http://coastal.ohiodnr.gov/education-outreach/lake-erie-facts-history>



CHAPTER 6 – SOURCE CONTROL PILOT STUDY

6.1 BACKGROUND TO PILOT STUDY

The City of Lakewood initiated a pilot study to examine the benefits of removing infiltration and inflow (I/I) on private property and in the public right-of-way from the sanitary sewer system. The Long Term Control Plan (LTCP) prepared in 2006 by the city recommended a pilot study to quantify stormwater removal effectiveness before designing a combined sewer overflow (CSO) storage facility. A source control program, directed toward public and private property, was initiated in 2014 and designed to evaluate policies and measures to reduce the volume of unnecessary storm and groundwater water entering the sanitary sewer system from private property sources. The program is being implemented by the city to assist in evaluating this water quality control measure citywide.

6.2 RECOGNITION OF CHALLENGES

- The city's sewer system receives significant I/I; complicated by a complex network of separate and combined sewers. In addition, the great majority of the separate sewer system is common trench, "over-under" construction with the storm sewer installed above the sanitary sewer and entering a common manhole. The sewers are separated in the manhole with a removable steel plate in the invert of the storm sewer.
- The result of a system-wide characterization study revealed approximately 66 existing overflows that eventually flow to the Rocky River and Lake Erie.
- The majority of rainfall that enters the sanitary sewer system comes from sources on private property. Rain water enters the public sanitary sewer due to the age of the overall system and the residential development in the city as most of the homes were built between 1900 and 1940.
- During rainfall events the sanitary and/or combined sewers become overloaded, but during dry weather there are no sewer capacity problems.
- Costs for rehabilitation work on private property can exceed expectations on what a homeowner can absorb.

6.3 GOALS OF THE PROGRAM

1. To improve water quality and achieve compliance with environmental regulatory agencies including the USEPA and the OEPA.
2. To reduce the volume of surface and subsurface water entering the sanitary sewer system.
3. To reduce overflows into the Rocky River and Lake Erie.
4. To reduce basement backups from the public system.
5. To develop an effective program while considering financial impact on the residents.



6. To provide baseline information and results in order to best evaluate the effectiveness of source control on a citywide basis.

6.4 THE PILOT STUDY PROGRAM

The program proceeded in four phases:

Phase I

- Begin flow monitoring to establish baseline flows
- Investigate and understand storm and sanitary utility connections in the right-of-way
- Hold public engagement meetings with the stakeholders
- Develop a preliminary concept for the selection and execution of a pilot study area

Phase II

- Hold second stakeholders meeting to initiate individual communication with the property owners
- Begin preliminary engineering to evaluate alternatives for corrective action on private property
- Determine financial and legal aspects of addressing private property rain and groundwater sources
- Develop a detailed program to proceed for the pilot study area with the following identified tasks:
 - Problem statement and strategy development
 - Financial plan
 - Public assistance program
 - Public education
 - Interim review meetings with city administration and City Council
 - Authorizing legislation

Phase III

- Perform thorough interior and exterior investigations for 102 properties within the pilot area
- Develop, bid, and award design-build contract documents for private property rehabilitation
- Provide 102 property owners rehabilitation quotes and receive 102 property owners authorization to opt-in the program and “right of entry” form to perform the quoted work
- Design, bid and build contract documents for the public right-of way rehabilitation work including manhole separations



- Ensure construction performance for both public contracts

Phase IV

- Evaluate post-construction flows in sanitary and storm sewers to evaluate effectiveness of pilot study work
- Consider application to entire sewer system

6.5 EXECUTION OF THE PILOT STUDY PROGRAM

6.5.1 PHASE I

A citywide flow monitoring program assisted in the development of a hydraulic model of the sewer system. Modeling was chosen as the most effective means to evaluate the sewer system and properly characterize its operation. The flow monitoring results led to a recommendation to focus on a three street area in the southwest portion of the city where flows could be more easily isolated and monitored apart from the larger sewer system. The streets included portions of Atkins Avenue, Eldred Avenue and Delaware Avenue. This is a residential area of 102 homes viewed to be a fairly typical mix of single and double family homes in the city (Figure 6-1). CCTV of storm and sanitary sewer mains, laterals and manholes in the public right-of-way performed.

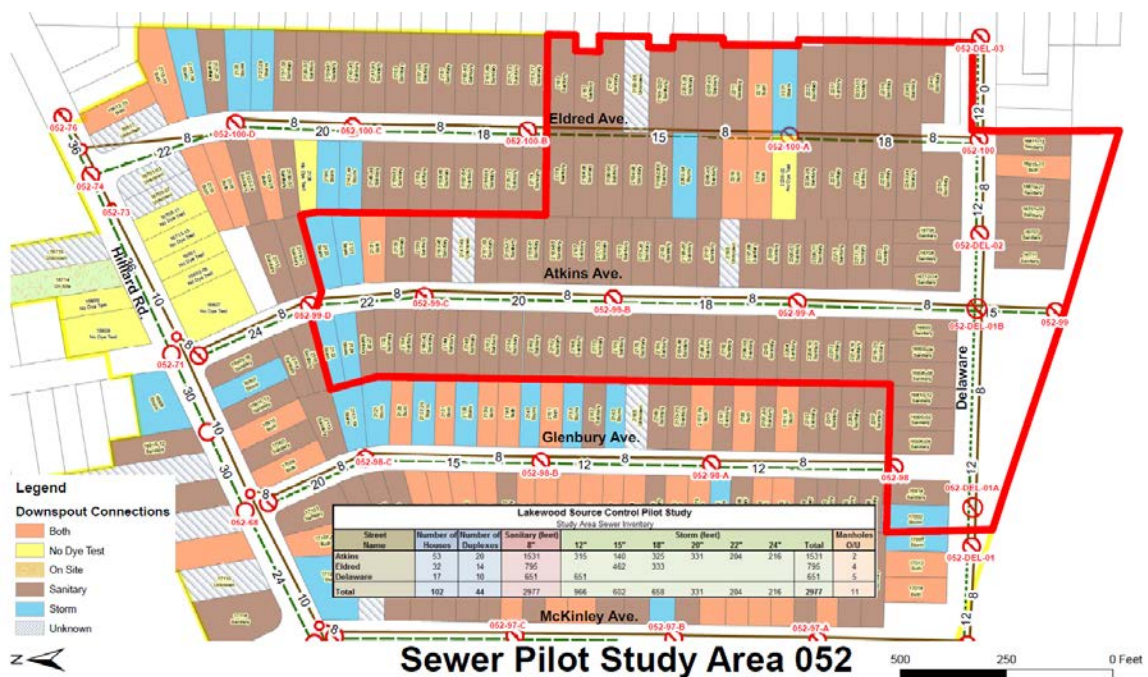


Figure 6-1: Source Control Pilot Study Area



6.5.2 PHASE II

Phase II began with research and a thorough review of the details associated with undertaking a correction program on private property to remove rain and groundwater sources leading to the sanitary sewer. In defining the problem and developing a strategy and work plan, the following issues were examined:

1. Potential costs of source control on public and private property
2. Methods and materials that would be needed for construction
3. Complicated sewer network with common trench installations; the storm sewer directly above the sanitary sewer with common manholes
4. Employee capacity to execute the program
5. Finding contractors experienced and proficient in this type of work
6. Engaging the public on these issues and the need for this pilot study
7. Determining the legalities of the city contracting work on private property
8. Determining what data is needed to validate assumptions in regards to private property connections to the sanitary and storm sewers
9. Reviewing Building Department records to understand construction practices in that era
10. Reviewing records of basement flooding
11. Internal and external investigations at each property
12. Evaluating the condition of the public sewer and what improvements are needed

An overall Work Plan Flow Chart was developed as a guide to implement this program (Figure 6-2). Additionally, various documents and records specific to the pilot area were obtained, including such items as; sewer construction drawings, GIS parcel data, phone complaints pertaining to backups or basement flooding, historical dye tests and downspout disconnections, and prior sewer cleaning and/or rehabilitation efforts. Research was performed on other private property I/I removal programs in order to learn from efforts in other cities.

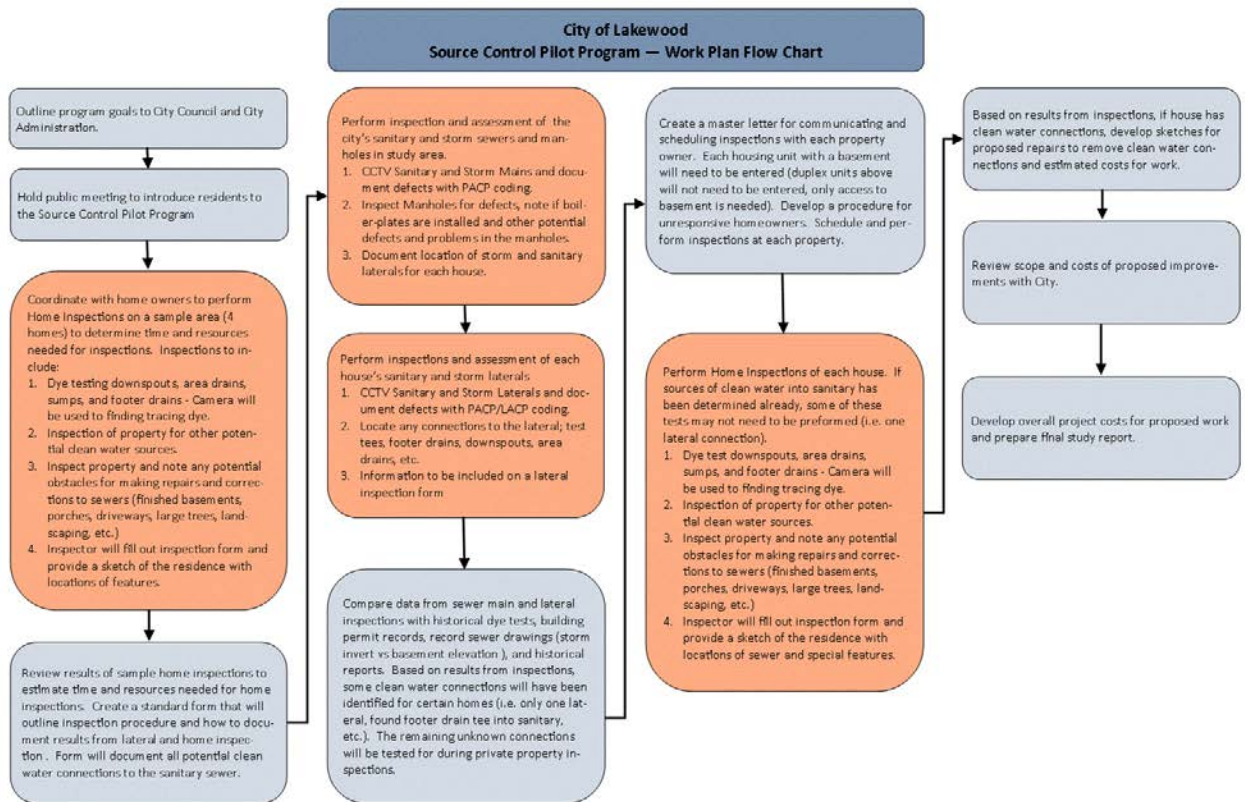


Figure 6-2: Source Control Pilot Study Work Plan Flow Chart

Legal Research

Several legal issues critical to executing this project were carefully reviewed and re-researched. The legal findings were important in providing proper guidance to move the project forward:

- Sanitary sewer laterals are the responsibility of the private property owner to the public right of way
- The city has the legal right to enter private property to conduct inspections and testing
- Current practices by the city indicate enforcement action is taken for the correction of illegal connections which are confirmed via dye-tests
- The city, in abating nuisance conditions, can authorize the use of public funds on private property
- Authorizing legislation is recommended to implement the program
- Probable costs need to consider allowances for property restoration claims
- City should seek formal release from the property owner upon completion of the work



Financing

Many options were considered for funding this pilot study program, including:

- City financed with homeowners paying city back over time
- 100 percent publicly funded
- 100 percent privately funded
- Public/private arrangement; i.e., shared cost and responsibility
- City creating a revolving loan program (similar to Ohio EPA's program to finance water quality improvements under the Water Pollution Control Loan Fund).
- Creating a new funding stream to cover costs

In determining how best to finance this pilot study, internal data and information gathering was completed, and goals and objectives of the project were introduced to City Council. The administration conducted meetings with City Council and all internal departments. Options were developed and discussed for a financial strategy to fund the work. In particular, it was clearly communicated that this pilot study was meant to provide the city with timely technical data to assist in evaluating the merits of source control as a cost-effective approach to addressing infiltration and inflow citywide.

Because of the need for timely data and results, the city elected for this pilot study only to fund 90 percent of the corrective action cost for each property based upon preliminary estimates of \$8,000 for each property. The property owner was given the option to pay their share or finance at zero percent interest via extra charges on their sewer bills over a 10-year period.

Legislation was prepared and approved by City Council that established a budget not to exceed \$900,000. The complete resolution reinforced existing city ordinances that declared any unnecessary water discharge to any sanitary sewer as a public nuisance (Attachment F). The legislation included the "Clean Water Pilot Project - Program Guide" that outlined the details of the program. This guide, developed by the city administration, set the pilot project area by address; explained the rationale and the city's authority for the pilot; provided some educational material related to I/I on private property; and, outlined the process and established the cost obligations and options for each property owner in the study.

The city moved forward with a detailed investigation of sewers on the public side and developed plans and specifications for repair and/or rehabilitation.

Project Management

The Lakewood City Engineer under the direction of the Director of Public Works was the administrator of the pilot study program. The city elected to hire a Project Manager under



the supervision of the City Engineer to ensure project performance due to the significant work load demands of the program. The job entailed a number of tasks, including: ensure all homes are inspected, develop and oversee a process of communication to inform and answer property owner questions, develop inspection standards, administer a program to conduct dye testing, and internal sewer televising, organize a data management system, and inform the city of findings and how best to adjust procedures based on interim findings.

Public Meetings

An initial public meeting was held on February 26, 2014 at Harding Middle School to introduce the program conceptually to residents in the selected neighborhood. The objective was to inform and educate property owners and to foster clear communication. Residents of the city were advised the city will be undertaking investigations in the public right of way as well. The city followed up with an additional mailing dated March 26, 2014 (Attachment F) that recapped the meeting and provided key slides from the presentation. On March 3, 2015, a second meeting was held once the pilot area was finalized and introduced the Council endorsed program guide titled "Clean Water Pilot Project - Program Guide" was released (Attachment F). The program guide was also posted on the city's website.

Field Investigations

In order to better understand the scope and magnitude of conducting physical inspections of each property, homeowners were asked to permit the city to perform an internal inspection.

Private property internal and external inspections were performed for each home consisting of an interview of the homeowner or tenant, physical observations, photographs, dye testing, sewer lateral televising, and foundation drain testing. Sketches of each home/basement and observations and testing results were logged and indexed by address and were also filed into the city's Web QA electronic platform.

Interpretations of the results from foundation drain testing, dye testing, CCTV results, age of home construction, sewer connections and building standards prior to 1930, physical observations, and flow monitoring data compiled prior to corrective action strongly suggested foundation drains, driveway drains and downspouts were connected to the sanitary sewer. In the public right-of-way, detailed field investigations included CCTV of the storm and sanitary sewer lines, photographs, and manhole inspections.

All field observed data was compiled and organized for review to help in evaluating potential corrective actions and their associated costs. It was also made available to prospective contractors to bid the work.



6.5.3 PHASE III

Private Property Corrections

The original work plan followed a traditional design/bid/build delivery system; therefore Phase III private property corrections would begin with the preparation of design details once enough information was gathered from record and field investigations. The lengthy time and cost required to produce bid documents and define the specific design correction for each property led to a discussion of alternatives.

The city elected to solicit input from contractors with expertise in residential plumbing who could offer more insight and options to address unique aspects of each property; and in particular, methods to overcome obstacles, such as front porches.

The input from the contractors influenced the city to choose a Design/Build (D/B) form of project delivery. It provides a single point of coordination giving the D/B contractor the option to perform all work or utilize subcontracted services. Detail design plans and technical specifications are replaced with a qualifications-based process for selection of a D/B contractor to assess each property and provide a detailed scope and quotation for the corrective work. The process is streamlined and improves the ability to treat each property with individual attention. The D/B contractor works for the city and will also be present to monitor progress and authorize payment. This prompted the next piece of legislation, included in Attachment F, which provided authority for the city to utilize the Design/Build project delivery system.

A Request for Qualifications (RFQ) for D/B was designed and published which required the submission of qualifications addressing specific questions and acknowledgement of the construction budget (Attachment F). The RFQ described the city's intent to have prospective D/B contractors conduct their own individual research of each property in order to submit a cost proposal for each one. Copies of the city's field investigations, records, dye tests and CCTV results were made available to each prospective bidder. Standard estimating forms were developed that included approvals from the city and the property owner. Interviews were held and a contract awarded to Underground Connections to execute the work. A copy of the legislation and the D/B Agreement is included in Attachment F.

The city took great care and consulted with outside legal counsel to establish a process designed to protect both the homeowner and the city, treating each property address as its own project. The contractor was directed to conduct his own due diligence and submit a scope of work and cost for each address in the pilot area for review by the city. The city sent packets to each property owner with the estimate and an opportunity to either opt-in, opt-out or contest the program. The packet also included a detailed description of the I/I



problems, test results and recommended solutions. For those selecting the opt-in, permission for entry by the contractor was provided; samples of these notices are included in Attachment F.

Failure for a property owner to reply to city communications could result in the disruption of water service (a copy of the letter is in Attachment F). Completed forms were forwarded to the contractor for scheduling the work with each property owner.

Preliminary estimates for correction were \$8,000 per home. In most cases, the corrective action was to re-direct the home's foundation drain to the city's storm sewer with the installation of an interior sump pump. Additionally, the downspouts and driveway drains were to be directed to storm lateral if they were currently directed to the sanitary. The estimate contemplated pipe bursting and sewer re-lining as potential options for rehabilitation of the sanitary sewer lateral.

The city elected to include a 10 percent contingency and based the program on a budget of \$900,000. The property owner was responsible for 10 percent of the actual cost for correction on their property and could either pay the city their final share upon completion and acceptance of the work; or, have the city include payment on their water/sewer bill financed at zero percent interest over 10 years. If the property owner elected to "opt-out" of the program, the property owner was required to retain their own contractor at their own cost and complete the corrective work to the city's satisfaction.

Private property work began in November of 2015 and was completed in August of 2016. All 102 property owners selected the opt-in option. Construction work revealed several immediate findings and validated evaluations from hydraulic modeling and included:

1. Most homes had no foundation drains; only a few homes needed sump pump installations.
2. Most storm sewer laterals were built with a buried service trap at the cleanout location near the right-of-way. The traps were clogged with sediment and debris. These service traps were eliminated and replaced with a straight through section of pipe containing a new storm cleanout (aka Test Tee). The presence of these traps likely increased stormwater migration from the storm sewer lateral to the sanitary sewer lateral.
3. Downspout and yard drains were re-directed to the storm sewer lateral.
4. Sanitary sewer laterals, for the most part, received a cured in place pipe (CIPP) Scrim Reinforced Flexible Felt Tubelining. In these cases the proximity of other service connections precluded pipe bursting.
5. In several cases, the contractor completed the CIPP lining or pipe bursting of the sewer lateral from the cleanout tee to the sewer main. Cost for this item was separated to distinguish it from the private property correction cost to properly account for the city's responsibility for any work in the public right of way.



6. The success of completing the program involved effective communication among all parties: the city and its administration, including the Law Department, Public Works Divisions of Engineering & Construction and Water/Wastewater Collection, City Council, the contractor, the property owner, engineering consultants and outside legal counsel.

After the work was completed, it was determined that individual property costs were significantly less than anticipated since sump pumps were not necessary. On average for the pilot study area, all corrective and repair work on private property averaged \$4,515 per property.

Public Sewer Rehabilitation

The traditional design/bid/build process was suited to the construction work in the public right-of-way. Detailed information from CCTV records and inspections of the manholes were studied to develop thorough recommendations for rehabilitation and/or repair of the sanitary sewer. Bid documents to reduce I/I in the sanitary sewer included the separation of all manholes in the pilot study area (complicated with re-connection of catch basin leads to the storm sewer manhole), storm and sanitary point repairs, sewer joint sealing, right-of-way lateral repairs, mainline sewer CIPP lining, and 3-foot lateral CIPP lining (aka top hat).

Construction contract documents were completed and bids were received in March, 2016 with a contract award to United Survey for \$854,080. At the time of this writing, construction is underway with a contract completion date of October 2016.

6.5.4 PHASE IV

Phase IV is to include post-construction flow metering to evaluate the effectiveness of the source control program. With a significant portion of corrective work completed on private property, flow metering was renewed in the spring of 2016 to obtain interim findings.

Figure 6-3 shows substantial flow reductions from a wet weather event in 2015 prior to beginning work on private property to a rain event in May 2016. The associated reduction in total volume and peak flow rates is shown as 73 percent and 39 percent, respectively, as seen on Table 6-1.

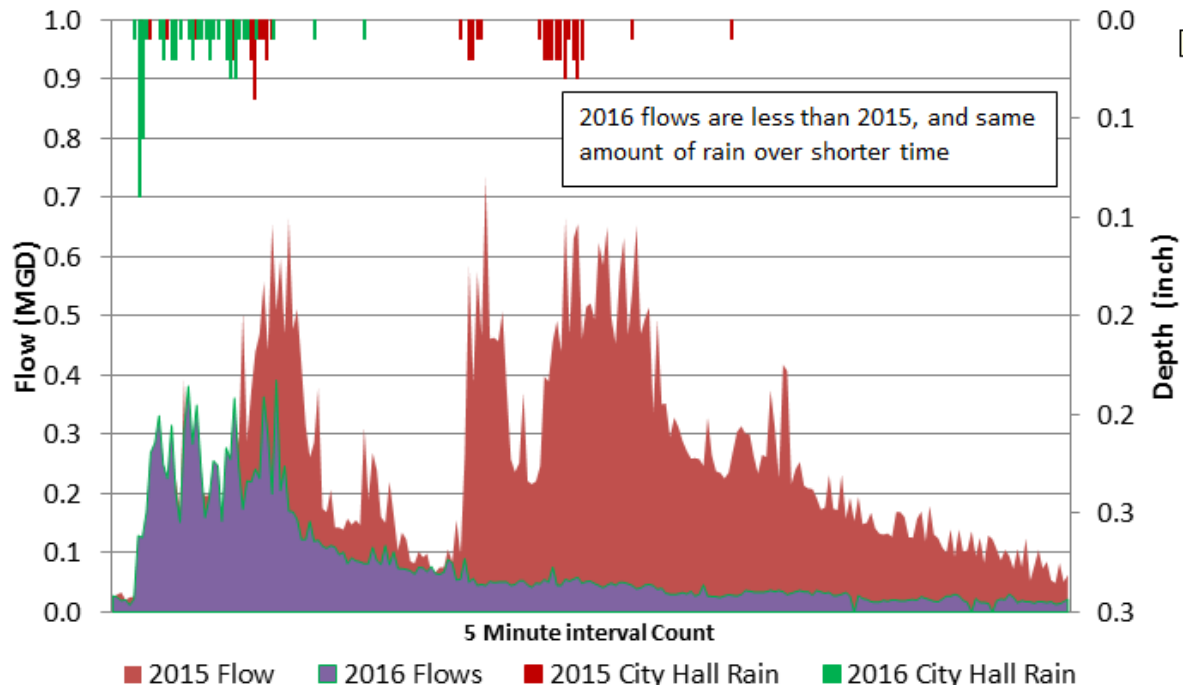


Figure 6-3: 0.5 Inch Rain, Pre-Construction vs. Partial Post-Construction

Table 6-1: Source Control Volume and Flow Reduction at 50% Construction Completion

	Pre-construction	Partial Construction	% Reduction
Volume (gallons)	368,712	98,446	73%
Peak Flow (mgd)	2.557	1.562	39%

Results to date show high reductions in flows, but more data is needed as the public-side construction work had not been done at the time of the monitoring. Flow monitoring in the near future will be key to understanding the role the pilot study played in reducing rain and groundwater from entering the sanitary sewer system. If results show significant reductions in flows, then applying source control to other areas of the city may play a key role in reducing overflows.



CHAPTER 7 – ENHANCED MODELING METHODS

7.1 INTRODUCTION

The City of Lakewood submitted a citywide Existing Conditions Hydraulic Model in 2014 to the Ohio EPA and USEPA. The Model included all storm, sanitary, and combined sewers and was calibrated utilizing local meter data from permanent and temporary meters. The report is titled *Integrated Wet-Weather Improvement Plan Hydraulic Modeling Technical Memorandum* and can be found as Attachment B.

The Existing Conditions Model is utilized as the base for developing enhanced modeling methods. Enhanced modeling is used to review a number of control strategies at various scales, such as: 1) impacts of a private property source control pilot study, 2) sewershed solutions suggested by the public, and 3) citywide source control implementation impacts (Figure 7-1). Each enhanced model built upon previous efforts and helped to develop a detailed model which incorporates ongoing and proposed work, as described throughout this report. This comprehensive, citywide model will be referred to as the *IWWIP Model*, as it is all inclusive of proposed source control, green infrastructure, high rate treatment, and miscellaneous smaller projects.

7.1.1 EPA SWMM LOW IMPACT DEVELOPMENT (LID) TOOLS

The USEPA Stormwater Management Model (SWMM) includes Low Impact Development (LID) tools, which allow the analysis of rooftop disconnection, green roofs, infiltration trenches, permeable pavement, rain barrels, rain gardens, bio-retention cells, vegetated swales, etc. This modeling tool allows an area (subcatchment) to be divided into various LIDs, allowing for greater control and understanding of the runoff characteristics. Runoff characteristics can then be used for calibration and analysis of both existing conditions and enhanced modeling efforts of the IWWIP model.

7.1.2 MODELING I/I IN SANITARY SEWERS

SWMM accounts for sewer infiltration by allowing a baseline flow or a flow unit hydrograph to be added at a sanitary manhole. Flow hydrographs (also known as RTK hydrographs) are developed from combining three individual hydrographs. Typically these three hydrographs represent the following:

1. Short-term flow –includes direct connections such as downspouts and illicit catch basin connections to the sanitary sewer.
2. Medium-term flow –includes a combination of ground infiltration and downspouts connected to foundation drains and sump pumps that may be connected to the sanitary system.



3. Long-term flow –includes ground infiltration that finds its way to the laterals and enters the sanitary sewer at poor joint conditions.

The hydrographs are built based on the percent of rainfall (R) estimated to be entering the sanitary sewer system, the time to peak flow (T), and a multiplier (K) that sets how long it takes for the flow to taper off.

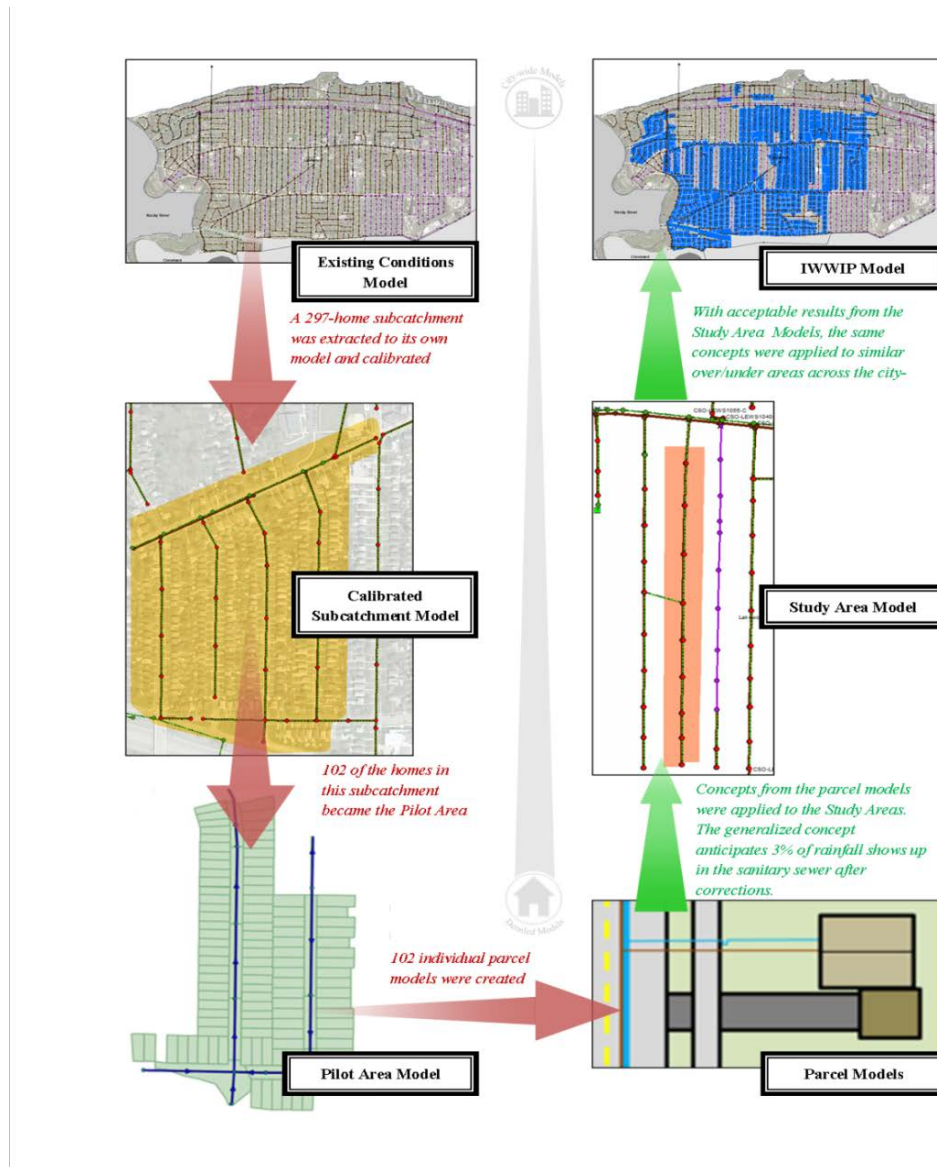


Figure 7-1: Enhanced Model Methodology



7.2 PARCEL LEVEL MODELING

The city initiated a pilot study to examine the benefits of removing infiltration and inflow on private and public property from the sanitary sewer system (details included in Chapter 6). The pilot study area is shown on Figure 7-2. The pilot study worked to understand the interaction of individual private property RC as opposed to street or sewershed-scale RC. A technical memorandum detailing the enhanced hydraulic model development and results is provided in Attachment G.

The pilot study included an investigation of the following:

- Televising public storm and sanitary sewer conditions
- Televising homeowner's sanitary lateral conditions
- Dye-testing and visually inspecting connections associated with: downspouts, driveway drains, sump pumps, and foundation drains.
- Flow monitoring the sanitary sewer to analyze flows during wet weather

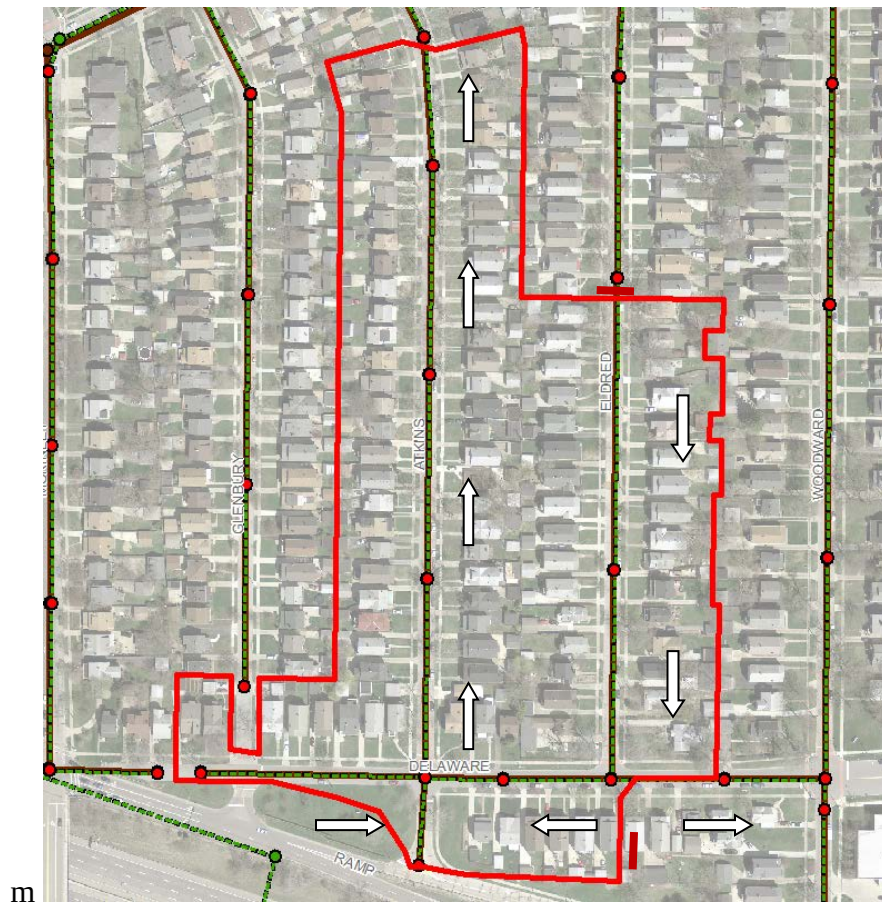


Figure 7-2: Source Control Pilot Study Area



7.2.1 EXISTING CONDITIONS OF THE PILOT AREA SEWER SYSTEM

The investigation indicated that the public sewers were over/under sewers that had deteriorated joints which would allow infiltration from the storm sewer into the sanitary sewer. Additionally, many invert plates were found to be not seated in the opening properly, providing a direct connection between the storm and sanitary sewers. Sanitary laterals were generally in disrepair with evidence of settling, root intrusion, and debris. Infiltration was observed to be prevalent.

Dye testing indicated that 98 percent of the downspouts appeared to be connected to the sanitary sewer directly or indirectly. Dye testing of the foundation soils was generally inconclusive; however, 5 percent had a dye response in the sanitary laterals. A typical private property piping configuration is shown in Figure 7-3.

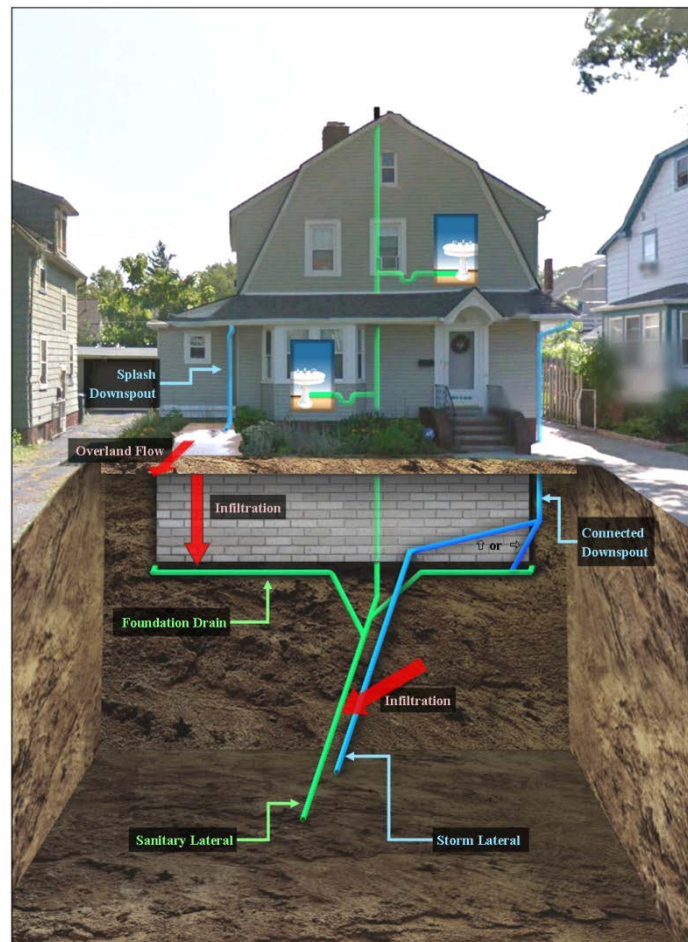


Figure 7-3: Typical Private Property Configuration



7.2.2 ENHANCED MODEL CONCEPTS

The input hydrograph values were found to be well above the values of a typical infiltration system model. Analyzing the volume and pattern of flow showed that the sanitary sewer was likely to have storm flow during wet weather events. Field inspection revealed manhole invert plates were not seated in the opening properly and were allowing flow between the sewers. Orifices were added to the model to reflect the direct leaks between the storm and sanitary system and to allow for accurate calibration.

The storm flow from private property also impacts flow in the sanitary sewer. Runoff hydrographs from each parcel were created to recognize the difference in runoff characteristics for roof drainage, pavement drainage, foundation drains, and yards. Figure 7-4 illustrates this typical RC layout developed for modeling the parcel runoff.

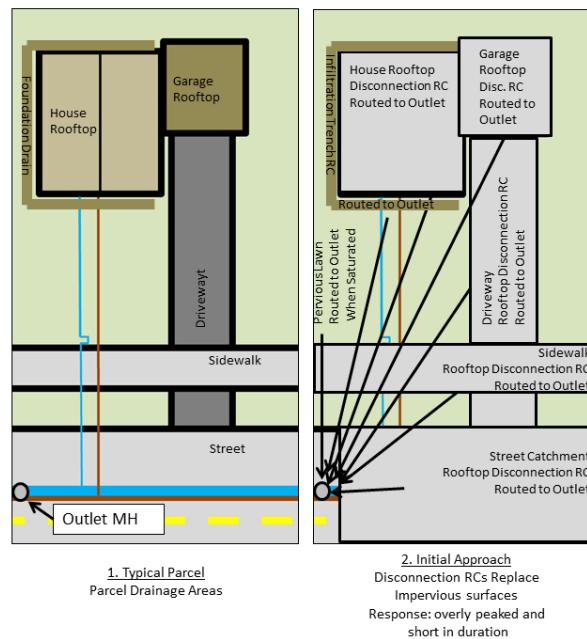


Figure 7-4: Initial Parcel Model Development: Understanding Runoff Characteristics from Different Impervious Surfaces

A site walkthrough determined that the 102 parcels in the pilot area could be categorized into 9 typical runoff RC scenarios that accounted for the portion of rooftops connected to the sanitary lateral (versus splashing to the yard), along with driveway drains and garage roofs. Figure 7-5 shows some typical downspout configurations. Calibration indicated that the observed sanitary peak flow was lower than if downspouts were directly connected to the sanitary sewer. The modelers hypothesized that gutters, downspouts or laterals were partially clogged and were slowly discharging stormwater to the sanitary sewer through secondary paths.



Figure 7-5: Typical Downspout Configurations

Figure 7-6 provides the model flows in comparison with the flow meter data after calibration. Calibration includes checks on velocity, depth, and flow because any excursions of one of those parameters might reveal impacts that need to be investigated.

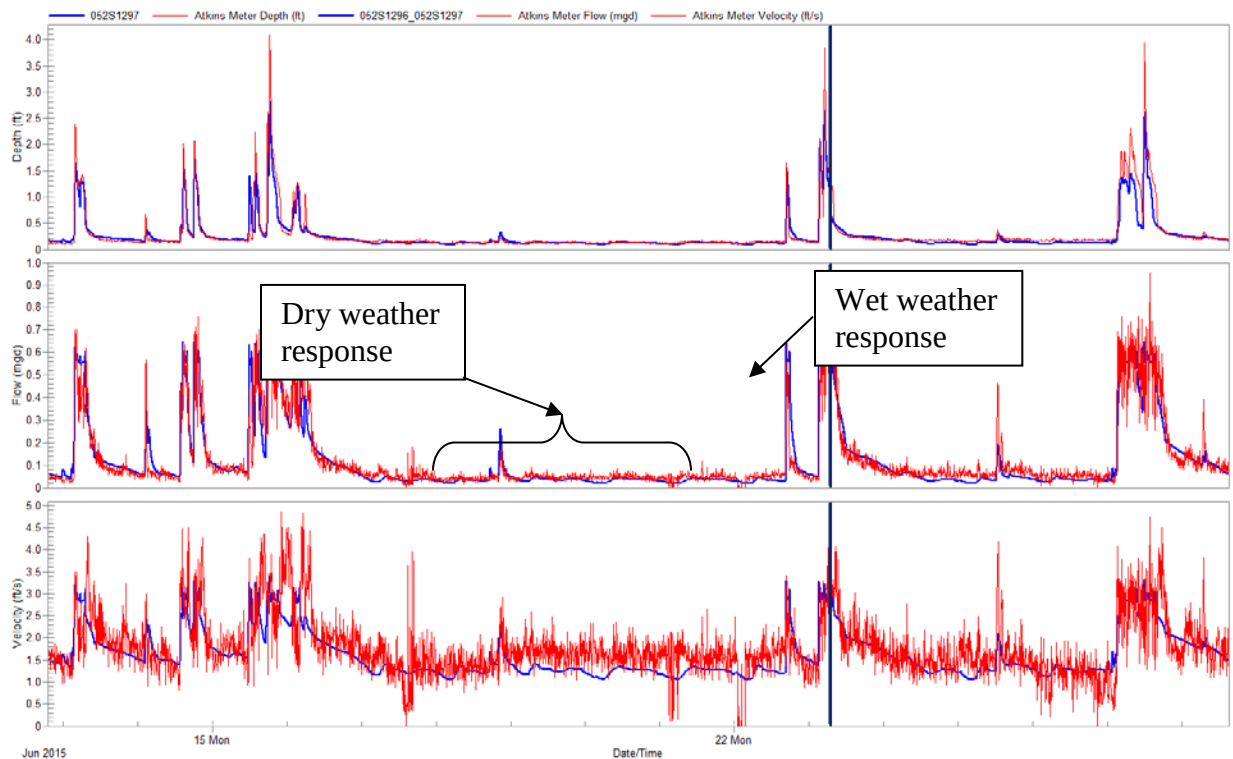
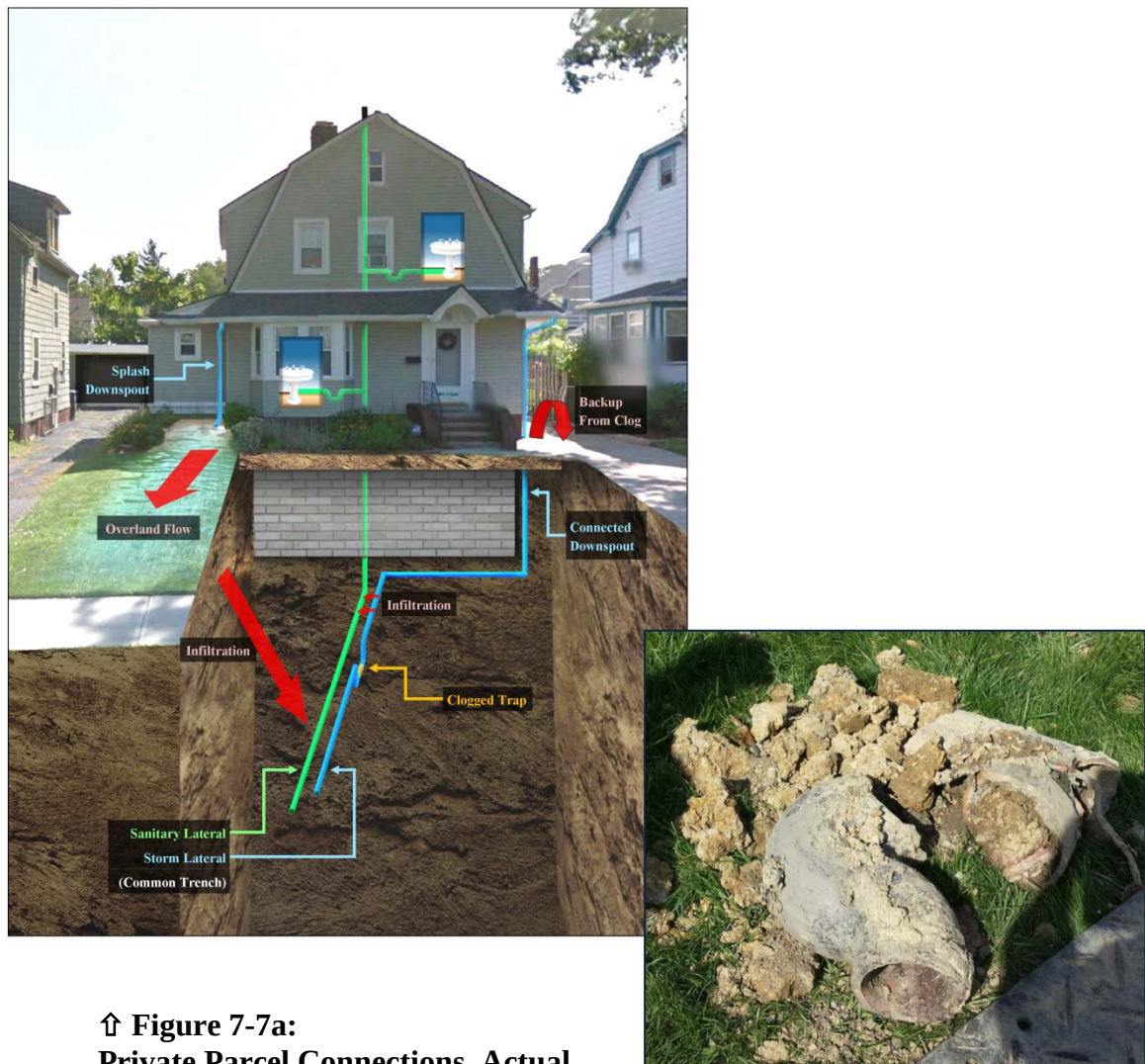


Figure 7-6: Calibrated Hydrograph for Pilot Study Area Existing Conditions

7.2.3 CONSTRUCTION OBSERVATIONS FROM THE PILOT STUDY

The pilot study included separating manholes, lining sanitary laterals on each property, and routing foundation drains/sump pumps to the storm sewer or lateral. Construction work on private property revealed the following issues:

1. Less than 10 percent of the properties had foundation drains.
2. The storm and sanitary lateral are in the same trench.
3. The storm lateral has a trap that was usually filled with sediment (Figures 7-7a and 7-7b) validating the modelers hypothesis that laterals were clogged.
4. Migration of flow from the clogged storm lateral to the sanitary lateral was significant.
5. Post-construction flow monitoring is expected to show that 3 percent of rainfall (R) is estimated to be entering the sanitary sewer system.



↑ **Figure 7-7a:**
Private Parcel Connections, Actual

↑ **Figure 7-7b:**
Trap Clogged with Sediment

7.3 MODELING METHODS: DEVELOPING APPROACHES

The Clean Water Lakewood Task Force suggested various approaches for wet weather control to be modeled and the results were discussed with them from December 2015-April 2016 (refer to Chapter 4). The public focused on finding solutions for four study areas (shown in red in Figure 7-8) with various sewer configurations.

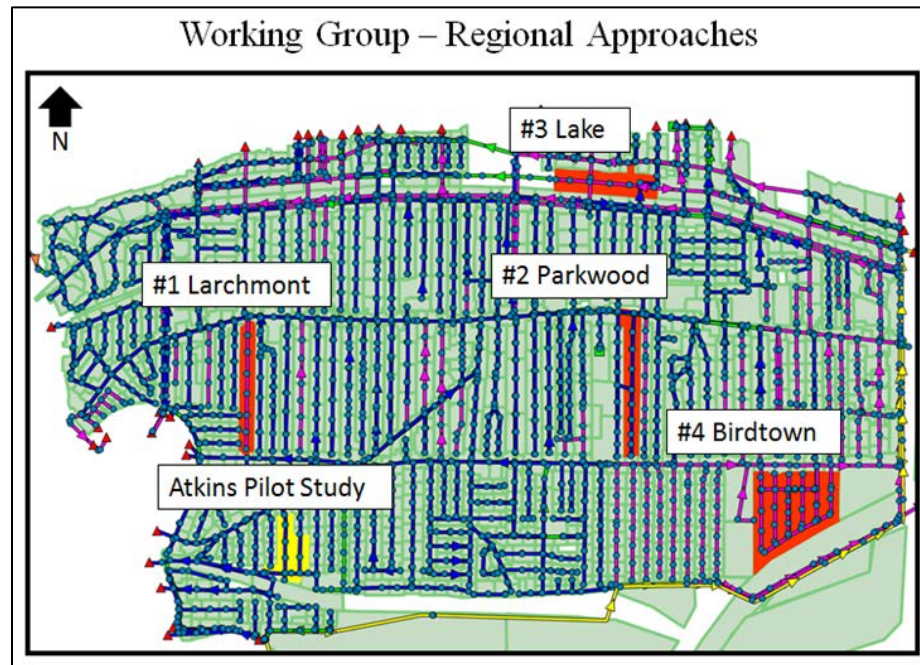


Figure 7-8: CWLTF Study Areas

The public had the following preferences for each study area:

1. Larchmont (combined sewer)–permeable pavement, bioretention, and sewer separation
2. Parkwood (over/under sewer)–source control, public sewer improvements (lining/manhole separation), and sewer upsizing
3. Lake(combined sewer)– permeable pavement, bioretention, downspout disconnection, and an underground storage tank
4. Birdtown (combined sewer)– bioretention on private property, school property, and within the right of way; green roofs, permeable pavement, sewer diversion, detention facility, and sewer separation

7.3.1 ENHANCED MODEL SUBCATCHMENTS AT THE PARCEL SCALE

To model the proposed conditions in combined sewer areas (Larchmont, Lake, Birdtown) the catchments were separated into five subcatchments in order to represent different surfaces and characteristics. This differs from the Existing Conditions Model which represented all surfaces within a subcatchment as having a one set of characteristics. Figure 7-9 shows how the study areas were broken down in the model.

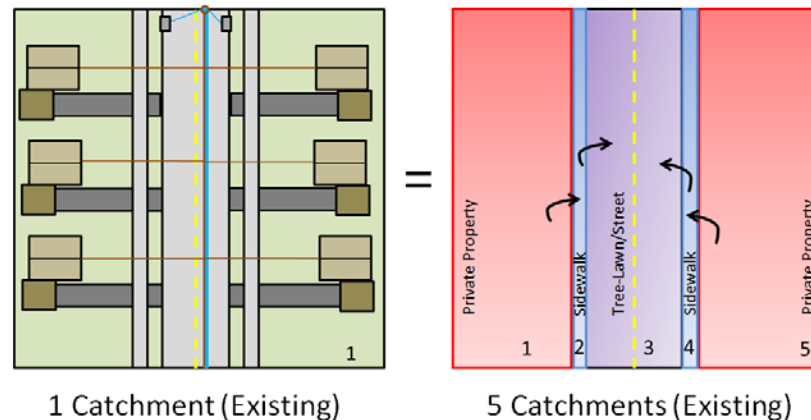


Figure 7-9: Depiction of How Study Areas were Broken Down in Model

Using the subcatchments at the parcel scale was determined to not be feasible citywide due to the level of detail, although the learning from that model was invaluable. Lessons from the pilot study such as: the level of I/I, and the P-traps being filled with sediment, were applied to street-scale study areas when approaching other O/U systems.

A detailed description of the models developed and the results produced as part of the working group study areas can be found in Attachment I.

7.3.2 MODEL FOR SOURCE CONTROL

The development of source control model was driven by knowledge gained through the pilot area study and the success of reducing flows to the sanitary sewer in the Parkwood (O/U sewer) study area model.

The pilot area study corrections are suggesting that a combination of private property work and public sewer rehabilitation can effectively reduce the amount of extraneous stormwater entering the sanitary system. The necessary improvements consist of the following:

- 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 comingling of flows at the invert plate locations

The existing pilot area conditions are depicted in Figure 7-10 while the corrected conditions are shown in Figure 7-11.



Figure 7-10: Existing Conditions in Over/ Under Sewer Areas

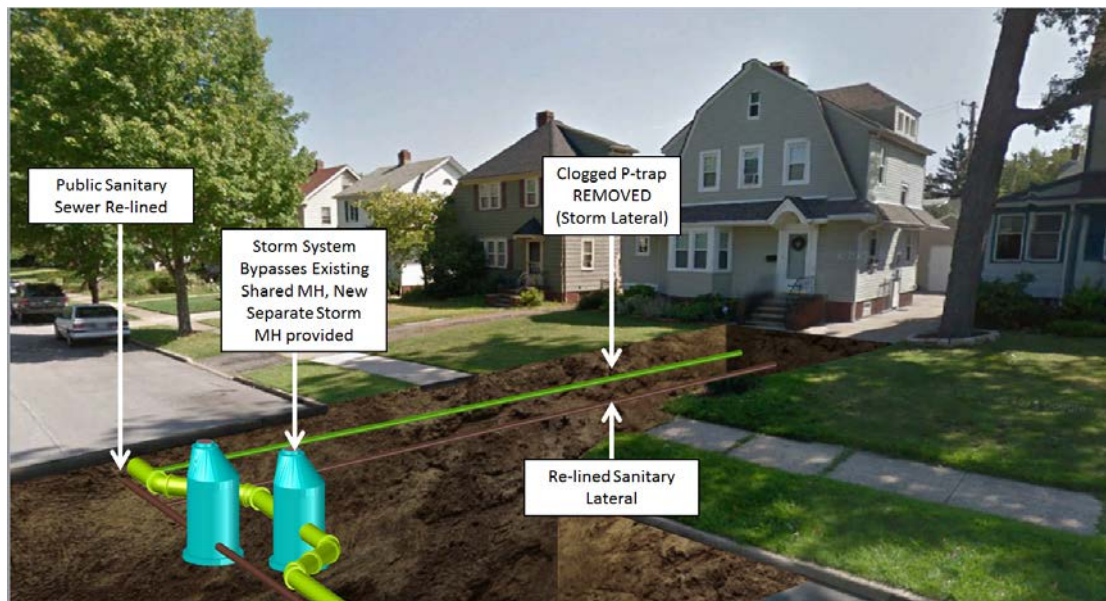


Figure 7-11: Post Construction Conditions for Source Control in Over/Under Sewer Areas

When modeling these Source Control improvements citywide, it was assumed that due to relining the public and private sewers, as well as separating all of the manholes, that the sewer system was sealed well-enough so that only 3 percent of the rainfall was leaching into the sanitary sewer.



It was also assumed that all clogged storm laterals would be cleared of debris, and all private property would have the stormwater sources properly connected to the stormwater lateral, not the sanitary. Lastly, it was assumed that the rear portion of each driveway would flow onto the pervious lawn surface. Results of the approaches, when applied within the context of the IWWIP Model, are discussed in Chapter 8 of this report.

7.3.3 GREEN INFRASTRUCTURE MODELING

The two types of GI preferred by the Clean Water Lakewood Task Force were modeled: 1) porous pavement sidewalk/drive aprons and 2) tree-lawn bioretention. These two structures would share a storage/infiltration bed beneath them.

The proposed bioretention features would include: a planted surface with two curb cuts, an overflow spill drain to avoid excessive ponding, a soil media layer for planting, and a rock storage layer beneath the soil. Each feature may also be outfitted with a drain system connecting to storm sewer where warranted. Comparison of existing vs. proposed conditions is in Figure 7-12a and 7-12b.

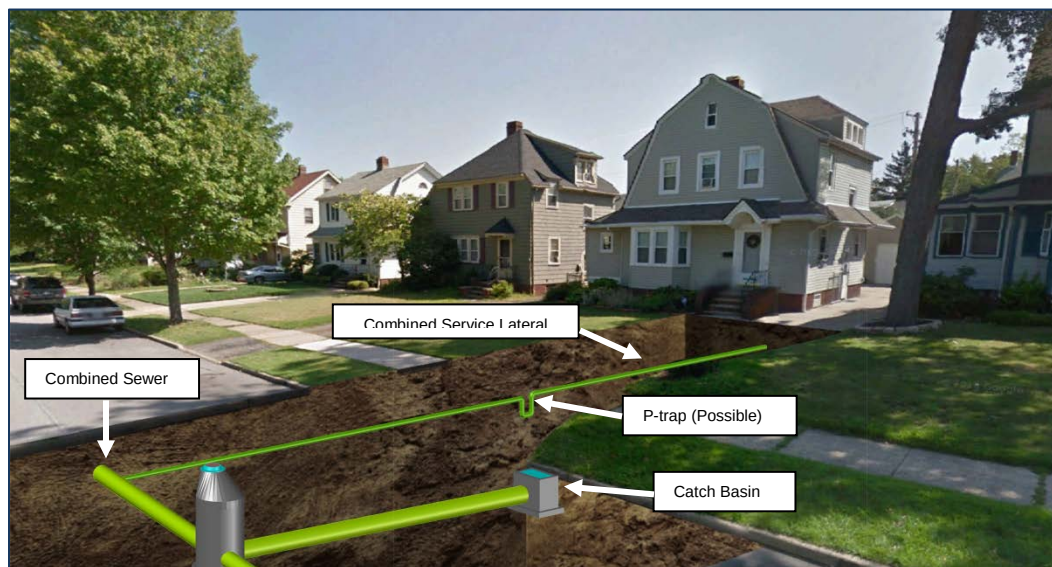


Figure 7-12a: Existing Conditions in Combined Sewer Areas

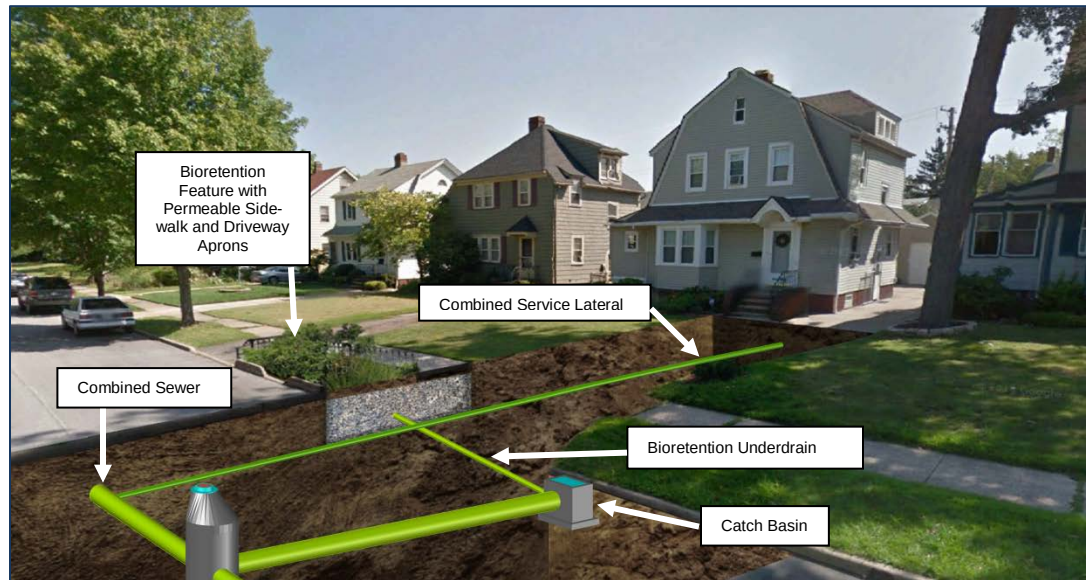


Figure 7-12b: Proposed Conditions for Green Infrastructure

7.3.4 ASSUMPTIONS IN THE GREEN INFRASTRUCTURE MODEL

Based on roadway linear footage and review of available space, the engineering team assumed approximately 50 percent of the road length was available for GI on each side of the road at a width of approximately 8 feet across the tree lawn and sidewalk.

It was also assumed that 50 percent of the impervious surfaces, such as rooftops were able to be routed to yards for infiltration. Meanwhile, the other 50 percent of impervious surfaces, such as sidewalks and driveways would be routed directly to the GI. Stormwater flooding the street would be routed to the GI as well. Approximately 5 percent of the impervious surfaces would still be flowing directly into the sewers.

Figures 7-13 and 7-14 illustrate the difference in runoff routing and treatment between existing and proposed conditions.

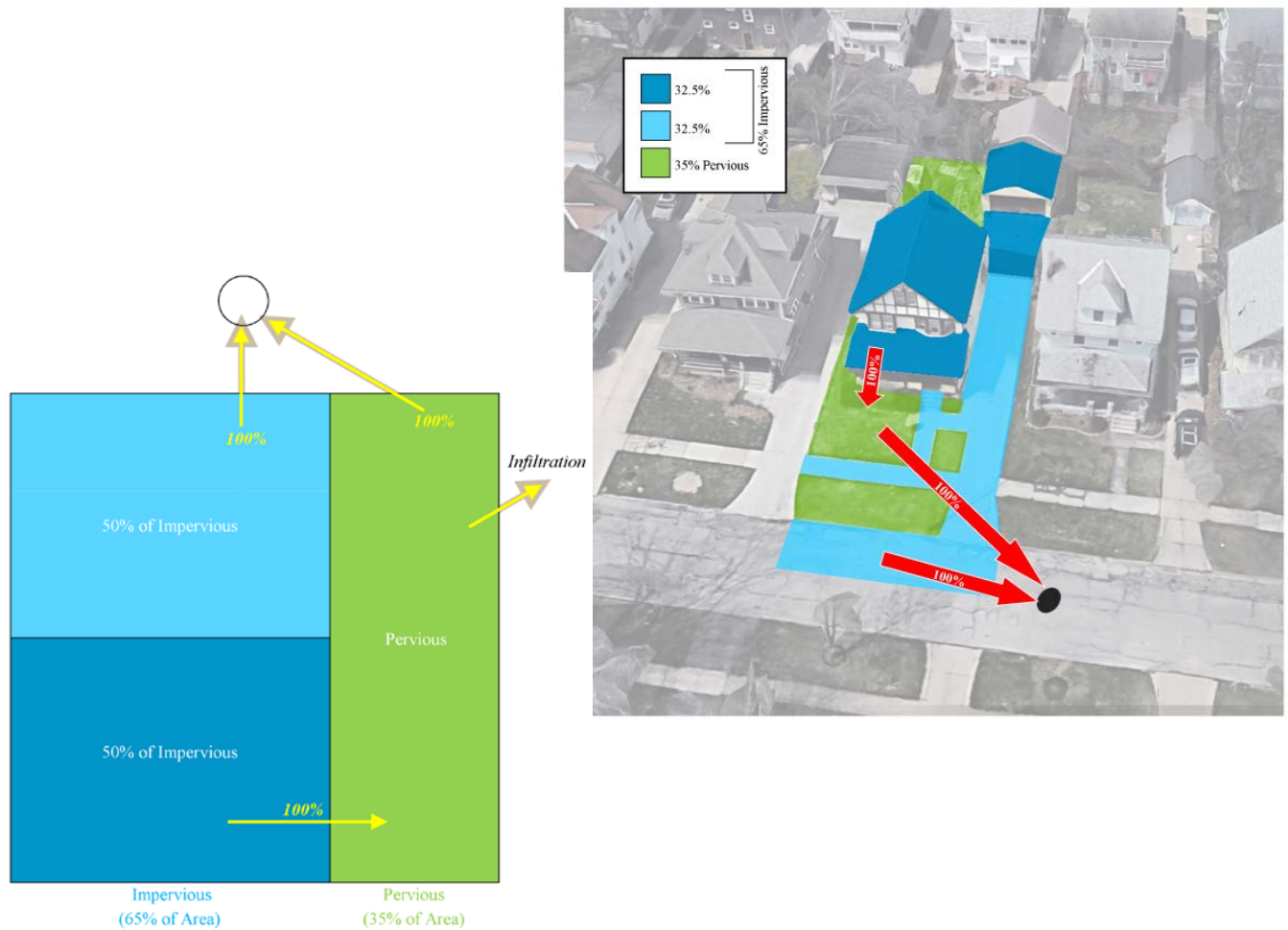


Figure 7-13: Existing Conditions Subcatchment Runoff Route

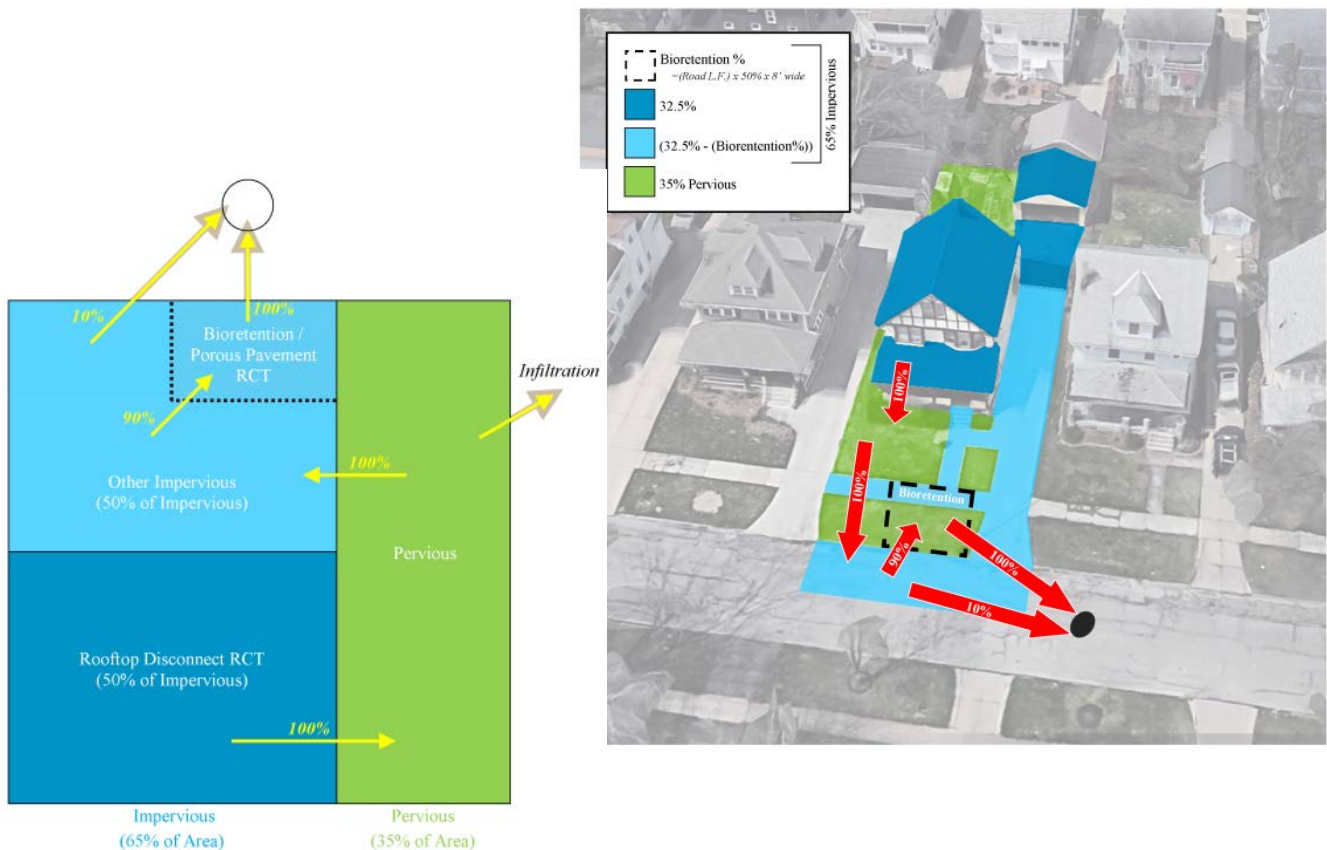


Figure 7-14: Proposed Conditions Subcatchment Runoff Route

7.4 MODELING METHODS: DEVELOPING CITYWIDE APPROACHES

Overflow control technologies that reflected the preferences of the Task Force include two principal strategies; source control and green infrastructure. The parameters developed for each in the study areas were applied to other areas within the city that had the same type of sewer construction.

Sewer-type was the main factor in determining which of these two strategies would be used in various locations around the city. Green infrastructure (GI) was used predominantly in combined sewer areas while source control was used in over/under sewer areas (Figure 7-15). GI was seen as most valuable in areas with combined sewers since GI has previously been shown to reduce stormwater volumes and peak flows. In an over/under system, source control would be the most valuable in ensuring that the rain and ground water is not entering the sanitary sewers.

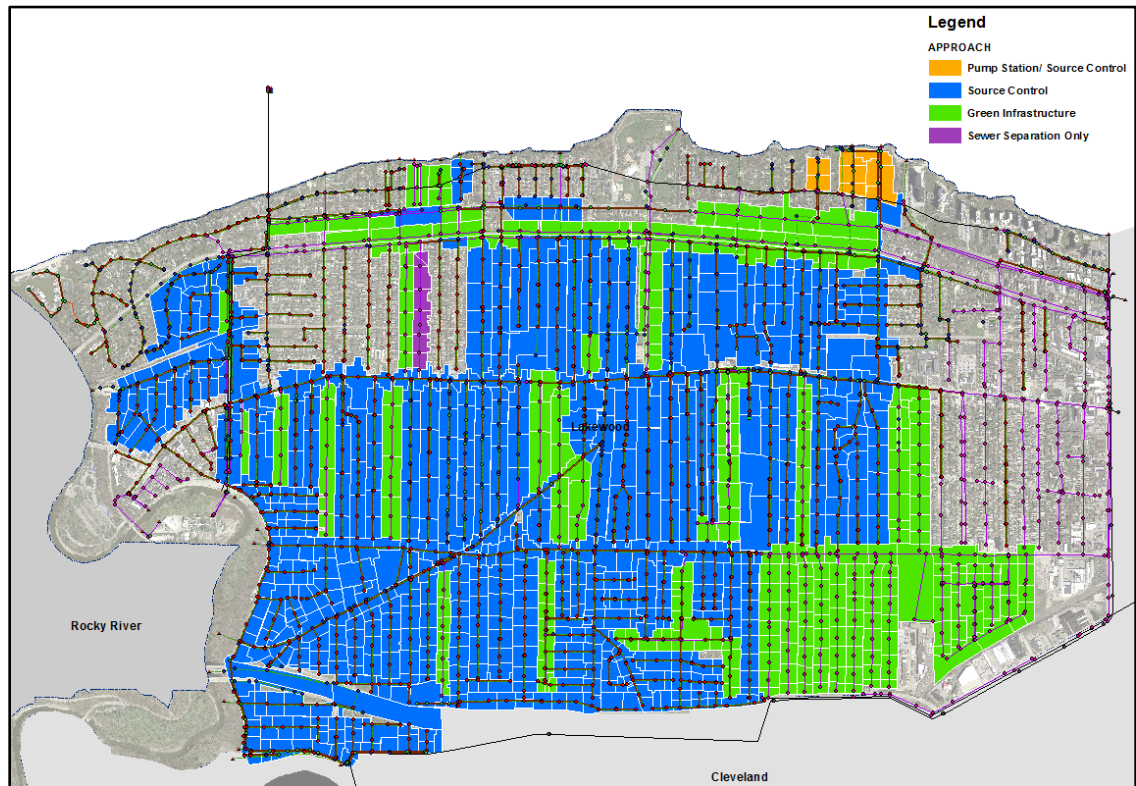


Figure 7-15: Citywide Approaches for Controlling Overflows



CHAPTER 8 – POTENTIAL CONTROL TECHNOLOGIES FOR OVERFLOWS

8.1 CONTROL TECHNOLOGIES

The technologies to be employed to “bring all sewage overflow discharge points into compliance with the technology and water quality based requirements” are far ranging and were considered in series and in combinations to attain compliance.

As mentioned in Chapter 2, over 78 technologies were evaluated in the 2006 LTCP for the nine CSOs (Attachment L). One result of that focus was that the LTCP source control technologies were determined to be not feasible for attaining compliance. Since 2006, further field investigations revealed the existence of more potential overflow locations, many of which are located at the ends of a single street or at multiple locations along a single street providing an opportunity to evaluate the effectiveness of source control. The source control technologies in the LTCP were not evaluated for the smaller catchments where source control could be effective.

Given the greater number of control locations in the system, technologies which had been considered “not feasible” or “feasible but not adequate” were reopened for consideration (Table 8-1). These technologies and others were presented to the Clean Water Lakewood task force (CWLTF) as a pallet of technologies to consider. Refer to Chapter 4 for a review of technologies reintroduced for consideration by the CWLTF. Technologies considered “feasible” in the LTCP were also reconsidered by the CWLTF and the engineering team in light of using these technologies at 66 overflow locations rather than 9 overflow locations since the efficiencies and impacts may be significantly different in smaller catchments.

8.2 SCREENING OF CONTROL TECHNOLOGIES

Control technologies considered in the IWWIP fell into three categories; 1) technologies required in the NPDES permit, 2) technologies preferred by the CWLTF and evaluated by the engineering team for effectiveness, and 3) technologies discussed with the CWLTF and evaluated by the engineering team for effectiveness without public comment. The screening process for each category is discussed in this section.


Table 8-1: Status of Control Technologies Considered

Technology	Status in IWWIP
Best Management Practices:	
Fertilizer and Pesticide Control	Evaluated in <i>Characterization of Pollutant Loads Technical Memorandum - Attachment C</i>
Infiltration/Inflow Control:	
Sewer and Manhole Rehabilitation	Evaluated by ET in pilot study area for Source Control. Technology considered by CWLTF.
Over and Under Sewer Rehabilitation (Invert Plates)	
Roof Leader and Footing Drain Disconnection	
Cross Connection Removal	
Stormwater Management Practices:	
Upstream Stormwater Storage	Technology would be implemented through bioretention. Technology considered by CWLTF and evaluated by ET.
Porous Pavement	Technology considered by CWLTF and evaluated by ET.
Infiltration Trenches and Basins	Technology considered by CWLTF and evaluated by ET.
Sewer System Optimization:	
Remove Bottlenecks (Pipe Capacity and Connection Hydraulic Improvements)	Technology considered by CWLTF and evaluated by ET.
Polymer Injection (Lining and Coating)	Evaluated in pilot study area for Source Control. Technology considered by CWLTF and evaluated by ET.
Regulator Optimization:	
Static Regulator Device Improvements	Technology considered by CWLTF and evaluated by ET.
Inter-Basin Flow Balancing/Relief:	
Inter-Basin Flow Transfer	Technology considered by CWLTF and evaluated by ET.
Sewer Separation:	
Complete and Partial Separation	Technology considered by CWLTF and evaluated by ET.
Subsurface Storage:	
Closed Concrete Tanks	Technology considered by CWLTF and evaluated by ET.
High-Rate End of Pipe Treatment:	
Ballasted Flocculation (Clarification)	Technology required by NPDES permit. Project is being designed by ET.
Increase Treatment Capacity of WWTP	Instituted by Lakewood WWTP staff after stress testing confirmed 40 mgd could receive secondary treatment on a short term basis.
Note: CWLTF = Clean Water Lakewood Task Force NPDES = National Pollution Discharge Elimination System ET = Engineering Team WWTP = Wastewater Treatment Plant	

8.2.1 TECHNOLOGIES REQUIRED BY THE NPDES PERMIT

Two specific technologies are required to be part of the IWWIP. They are:



- Submit “*design criteria for the High Rate Treatment System Initial Control Measure*”. The Permit acknowledges that “*The City of Lakewood has proposed constructing a high rate treatment system at or near the wastewater treatment plant as the Initial Control Measure.*”
- Source control which by the Permit requires Lakewood to “*consider possible outcomes of the pilot sewer separation study in development and evaluation of control alternatives.*”

The High Rate Treatment (HRT) system is proposed for construction at the Lakewood WWTP with a design capacity of 35 mgd. A pilot plant was located at the WWTP in 2015 and the study results are provided in Attachment D. The design criteria Technical Memorandum is included in Attachment E of this report.

A source control pilot study area was identified by the city in 2013 to evaluate if sources of I/I from private property, when coupled with improvements to the public sewer, can reduce I/I to a level that will deactivate or eliminate overflows and occurrences of basement backups from the public system.

8.2.2 TECHNOLOGIES CONSIDERED BY THE CLEAN WATER LAKEWOOD TASK FORCE

Having been given exposure to a variety of technologies that were identified in the LTCP as well as BMPs from other sources, the CWLTF was asked to study and express preferences for technologies that they felt best represented the values that Lakewood has, as well as the vision for the future of Lakewood. The CWLTF was divided into four workgroups each assigned a study area representing various types of sewer configurations. Each study area also had an overflow regulator that was similar to others in other parts of the city. Consequently, the preferences developed for each groups study area was applicable to other areas of the city with like sewer and overflow configurations.

The preferences developed by each work group were modeled for each study area to determine the effectiveness of technology in controlling overflows. The modeling results were reported back to each work group. Successful technologies were incorporated into the IWWIP for the study area and similar areas in the city. Unsuccessful technologies were taken back to the work group for refinement. The refinements were modeled and if the results brought overflows into compliance, the technologies were incorporated into the IWWIP for the study area and similar areas in the city.

8.2.3 GREEN INFRASTRUCTURE (GI) TECHNOLOGIES

The CWLTF reviewed a large number of GI technologies. Consideration was given to soil type, available land, drainage patterns, and other pertinent factors. The only restrictions placed on the task force was that any GI proposed for the IWWIP had to be on



public property or on land that could be acquired for public use. This restriction was placed on this technology so that the technology would be perpetually controlled, maintained, and dedicated to the stated purpose.

GI was preferred by the CWLTF because the model showed it to be effective and it reflected the values contained in the Lakewood's Community Vision Master Plan, specifically to *"Become a regional leader regarding storm water management."*

8.2.4 TECHNOLOGIES CONSIDERED BY THE ENGINEERING TEAM

Among the technologies considered for the IWWIP, there were some technologies that were considered too technical for the general public to evaluate. These technologies were to be considered where modeling indicated a sewer system problem that needed to be understood using hydraulic calculations for the basis of the evaluation. An example of this type of evaluation included surcharging of the interceptor resulting in backwater conditions in local sewers. The areas that fell into this category were rather small and principally located along the lakeshore.

8.3 CONTROL TECHNOLOGIES IMPLEMENTED

In advance of the IWWIP, certain control technologies were implemented by Lakewood to mitigate overflows where either:

- The control technology could be implemented without unintended impacts on other portions of the sewer system; or
- A technology recommended in the LTCP could be implemented without unintended impacts on other portions of the sewer system.

Lakewood's analysis of the former category became embodied in an Administrative Consent Order that outlined the implementation of an Early Action Project Plan to address seven overflow locations. The latter category was a project that controlled overflows from two CSOs on the west end of the city. A discussion of each of the projects follows.

8.3.1 TECHNOLOGIES IMPLEMENTED THROUGH THE EARLY ACTION PROJECT PLAN

An Administrative Consent Order, issued by the USEPA in 2013, identified seven overflows that Lakewood agreed to investigate and address through construction of Early Action Projects which would result in controlling overflows at the following locations:

- EAP-1: Brockley Avenue at Clifton Boulevard
- EAP-2: Cannon Avenue at West Clifton Boulevard
- EAP-3: West Clifton Boulevard at Clifton Boulevard
- EAP-4: Webb Road at Clifton Boulevard



- EAP-5: Summit Avenue at Edgewater Drive
- EAP-6: Thoreau Avenue at City Hall connection
- EAP-7: Clifton Boulevard at Emerson School

As of the date of this document, all projects except EAP-5 have been completed; the overflows have been remediated and are no longer listed as overflows. Flow monitoring and further detailed investigation of the overflow in project EAP-5 indicated that even further analysis and evaluation of cost-effective control alternatives was warranted through the IWWIP.

8.3.2 VOLUNTARY IMPLEMENTATION OF LTCP TECHNOLOGIES

The LTCP recommended that sewers in the west end of the city be diverted from an influent pump station at the WWTP to the interceptor in West Clifton Boulevard as cost effective to remove overflows from two locations; CSO 053 and CSO 054. The city's LTCP proposed to intercept the flow tributary to CSO-053 and redirect it to the city's main interceptor located on West Clifton Boulevard. This sewer would also intercept combined sewage from the CSO-054 area to limit the overflows to less than four in a typical precipitation year.

The method of construction identified in 2006 was conventional open-cut construction but with a note that "*micro-tunnel construction methods may be appropriate for construction of the sewer.*" Open-cut construction was determined to be infeasible given the severe impacts to traffic, utilities, and commerce along Detroit Avenue.

An alternative alignment and construction by tunneling was determined to be feasible, but costs greatly exceeded initial construction estimates in the LTCP. A third alternative was evaluated involving construction of an aerial sewer from the south end of Scenic Street over the Rocky River and to the headworks of the WWTP (Figure 8-1).

The West End project under construction and is expected to be placed into service in November 2016. When complete, it will eliminate CSO 053 and CSO 054, two of the city's three permitted overflows to the Rocky River.



**Figure 8-1: West End CSO Elimination Project Results
in Controlling CSO-053 and CSO-054**

8.4 CONTROL TECHNOLOGIES SELECTED

The control technologies selected for inclusion in the IWWIP were evaluated through modeling using the techniques previously discussed in Chapter 7 with all of the technologies eventually applied to the entire city. The comprehensive Existing Conditions Model was run with all of the control technologies in place for a typical year of rainfall. When evaluating control technologies, it was understood by the CWLTF and the engineering team that for a particular control technology to be successful, other control technologies need to be incorporated that may work in series or parallel.

For example, the study group that looked at a street with a combined sewer and an overflow at the end of the street preferred removing storm water from the combined sewer using of green infrastructure (GI). The GI would be implemented through two technologies (porous pavement and bioretention) working in parallel to store and infiltrate runoff. The GI was very effective in removing storm water from the combined sewer and would deactivate the overflow if there were no hydraulic influences from the sewers downstream of the overflow. In cases where the downstream sewer (usually and over/under configuration) had excessive I/I impacting available capacity, source control might be the tech-



nology considered to remove I/I; increasing downstream capacity, and allowing the green infrastructure to effectively deactivate the overflow.

The above example is used to illustrate the need to evaluate all of the technologies when they are strategically placed in the sewer system, and then their associated impacts, both upstream and downstream, can be fully realized and evaluated. Therefore, the final evaluation of the effectiveness of the IWWIP was through an integration of technologies required by the NPDES permit, preferred by the CWLTF, and selectively located by the engineering team.

Table 8-2 provides the control technologies used for each identified overflow location and the occurrences of overflows after deploying all technologies. A discussion of the technologies used to bring each overflow into compliance is provided in Section 8.5. Maps illustrating the areas where the technologies are to be deployed are shown for each overflow location in Figures 8-2 through 8-22a following page 100. The overflows that correspond to each figure are referenced in Table 8-2.

8.5 PROPOSED CONTROL TECHNOLOGIES FOR OVERFLOWS AND MAPS

The proposed control technologies proposed in the IWWIP are discussed in this section. For consistency with the MS4 identification protocol, the overflows are listed by outfall designation and then by a suffix indicating successive overflows, beginning with the overflow closest to the outfall and progressing upstream. For example LEWS1040-C is upstream of outfall LEWS1040 and is the third overflow upstream of the outfall.

The first four letters of the outfall name indicate the receiving water. LEWS indicates Lake Erie Water Shed, RRES indicates Rocky River East Side, and RRWS indicates Rocky River West Side. Numbering proceeds east to west along the Lake Erie shore and from the mouth of the Rocky River proceeding upstream. Refer to Figure 3-1 for a map showing the overflow and outfall locations. Overflows identified in the NPDES permit (in parenthesis) are included where they coincide with outfall designations.

LEWS1035-A (CSO 059)

This overflow is located on the interceptor and is the furthest upstream overflow on the interceptor. This overflow is impacted by flow in the interceptor only; local sewers do not influence overflows in this location. The regulator consists of a weir running longitudinal along the interceptor and set at the crown of the interceptor pipe. Overflows occur only when the interceptor is surcharged.

The biggest influence on overflows at this location is upstream flow from the network of sewers on W. 117th Street which constitutes the “headwaters” of the interceptor. During



wet weather, upstream flow can account for 50 percent of the flow at the head end of the interceptor.

Two alternative technologies were evaluated based on CWLTF preferences; 1) storage of excess flows in the vicinity of LEWS1035; and 2) diversion of all flow to the NEORSD Northwest Low Level Interceptor upstream of the Lakewood interceptor flow splitter. Either alternative selected would reduce the overflow to zero events in a typical year of rainfall.

LEWS1035-B

This overflow is located at the intersection of Thoreau Avenue and Clifton Boulevard. The sewers on Thoreau consist of common trench side-by-side sewers with the storm sewer generally deeper than the sanitary sewer. Field investigations revealed that the storm sewer flows constantly with a mixture of sewage and clear water. It is though the storm sewer has sewage in it because it is deeper than the sanitary sewer and therefore can serve basements. The regulator at the north end of the street at Clifton Boulevard consists of an invert plate partially ajar so that low flow from the storm sewer drops into the sanitary sewer while wet weather flow leaps over the invert plate to a storm sewer exiting the manhole. The Thoreau Avenue sanitary sewer connects to the Clifton Boulevard sanitary sewer using a wye connection (not visible in the manhole).

Source control and cross connection removal is the technology employed for this overflow to return the function of the storm sewer to conveying clear water only and the sanitary sewer conveying only sewage.

LEWS1040-A

This regulator is located at the north end of Nicholson Avenue at Lake Erie on a local sanitary sewer. This local sewer connects to interceptor through the sanitary sewers on Cliff Drive and Wilbert Avenue. The Wilbert Avenue sanitary sewer connects to the interceptor below the spring line of the interceptor. When the interceptor flows at its full capacity, the flow on Wilbert backs up to Nicholson Avenue and overflows to LEWS1040-A.

The technology planned is to construct a pump station serving the local Wilbert Avenue, Cliff Drive, and Nicholson Avenue sewers to hydraulically break the connection to the interceptor. The sewage from these streets will be pumped into the interceptor so that the hydraulic grade of the interceptor does not impact the local sewers in this area. Source control will be employed in the service area upstream of the pump station to mitigate wet weather impacts on flow that could require oversizing the pump station. The installation of a new pump station and source control would reduce the overflows to zero events in a typical year of rainfall.

**LEWS1040-B**

This overflow is located at the intersection of Clarence Avenue and Detroit Avenue. The sewer on Clarence is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that that installation of green infrastructure (permeable paving and bioretention) on Clarence coupled with source control on Clarence will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.066 Mgal.

LEWS1040-C

This overflow is located at the intersection of Grace Avenue and Detroit Avenue. The sewer on Grace is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) on Grace along with source control on Grace will reduce this overflow to zero events in a typical year of rainfall.

LEWS1040-D

This overflow is located on Detroit Avenue east of Elbur Avenue. It is located in a manhole on a sewer conveying combined sewage. The overflow is a pipe higher up in the manhole that activates when the sewer surcharges. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) along with source control for all streets south of Detroit Avenue within the LEWS1040 drainage area will reduce this overflow to three events in a typical year of rainfall discharging a volume of 0.039 Mgal.

LEWS1040-E

This regulator is located at the intersection of Elbur Avenue and Detroit Avenue. It is located in a manhole on a sewer conveying combined sewage. The overflow is a pipe higher up in the manhole that activates when the sewer surcharges. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) along with source control for all streets south of Detroit Avenue within the LEWS1040 drainage area will reduce this overflow to zero events in a typical year of rainfall.

**LEWS1040-F**

This regulator is located at the intersection of Wyandotte Avenue and Detroit Avenue. The sewer on Wyandotte is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator and flows over a low weir wall to a pipe connected to the storm sewer. Modeling indicates that that installation of green infrastructure (permeable paving and bioretention) and source control technology when coupled with source control for all streets south of Detroit Avenue within the LEWS1040 drainage area will reduce this overflow to zero events in a typical year of rainfall.

LEWS1040-G

This regulator is on the combined sewer on Madison Avenue at the intersection of Lewis Drive. A pipe overflow connects to the storm sewer on Lewis Avenue. Modeling indicates that green infrastructure (permeable paving and bioretention) and source control technology for all tributary upstream combined sewers areas coupled with installation of a 24-inch diameter relief sewer on Madison Avenue between Lewis Drive and Chesterland Avenue will reduce this overflow to four events in a typical year of rainfall discharging a volume of 0.705 Mgal.

LEWS1040-H

This regulator is located at the intersection of Elbur Avenue and Madison Avenue. A weir separates the Madison Avenue combined sewer from the storm sewer on Elbur Avenue. Modeling indicates that green infrastructure (permeable paving and bioretention) and source control technology for all tributary upstream combined sewers areas coupled with installation of a 24-inch diameter relief sewer on Madison Avenue between Lewis Drive and Chesterland Avenue will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.005 Mgal.

LEWS1045-A

This regulator is located at north end of Wilbert Avenue at Lake Erie. This overflow is impacted by the same hydraulic dynamics as LEWS1040-A since it is located on the same local sewer system connected to the interceptor.

The technology planned is to construct a pump station serving the local Wilbert Avenue, Cliff Drive, and Nicholson Avenue sewers to hydraulically break the connection to the interceptor. The sewage from these streets will be pumped into the interceptor so that the hydraulic grade of the interceptor does not impact the local sewers in this area. Source control will be employed in the service area upstream of the pump station to mitigate wet weather impacts on flow that could require oversizing the pump station. The installation



of a new pump station and source control would reduce the overflows to zero events in a typical year of rainfall.

LEWS1055-A

This outfall is primarily storm sewer flow except for a small amount of combined sewage from Lake Avenue between Homewood Avenue and Nicholson Avenue. The combined sewer on Lake Avenue will be disconnected from the storm sewer at Lake Avenue and Wilbert and rerouted to a new 36-inch combined sewer that will run north on Wilbert Avenue from Lake Avenue to the interceptor on Edgewater Drive. LEWS1055 will become a storm outlet only except for overflows from LEWS 1055-C, D, &E and the regulator on Edgewater Drive will be disconnected from the Interceptor.

LEWS1055-C

This regulator is located at the intersection of Parkwood Avenue and Detroit Avenue. The sewer on Parkwood is an over/under sewer that connects to the combined sewer on Detroit Avenue. An overflow is located in the manhole in the intersection on a sewer conveying combined sewage. The overflow is a pipe higher up in the manhole that activates when the sewer surcharges. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) along with source control for all streets south of Detroit Avenue within the LEWS1055 drainage area will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.008 Mgal.

LEWS1055-D

This regulator is located at the intersection of Robinwood Avenue and Detroit Avenue. The sewer on Robinwood is a combined sewer that connects to the combined sewer on Detroit Avenue. A regulator directs dry weather flow to the combined sewer on Detroit. Wet weather flow backs up in the regulator and flows over a low weir wall to a pipe connected to the storm sewer. Modeling indicates that that installation of green infrastructure (permeable paving and bioretention) and source control technology when coupled with source control for all streets south of Detroit Avenue within the LEWS1055 drainage area will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.002 Mgal.

LEWS1055-E

This regulator is on the combined sewer on Cedarwood Avenue at the intersection of Blossom Park Avenue. A pipe overflow connects to the storm sewer on Blossom Park Avenue. Modeling indicates that green infrastructure (permeable paving and bioretention) and source control technology for all upstream combined sewers will reduce this overflow to zero events in a typical year of rainfall.



LEWS1070-A

This regulator is located at the north end of Homewood Avenue at Lake Erie on a local sanitary sewer. This local sewer flows south from the cul-de-sac to the interceptor where it connects below the spring line of the pipe. When the interceptor flows at its full capacity, the flow on Homewood backs and overflows to LEWS1070-A.

The technology planned is to construct a pump station at the intersection of Homewood Avenue and Edgewater Drive. The sewage from Homewood will be pumped into the interceptor so that the hydraulic grade of the interceptor does not impact the local Homewood sewer. Source control will be employed in the service area upstream of the pump station to mitigate wet weather impacts flow that could require oversizing the pump station. The installation of a new pump station and source control would reduce the overflows to zero events in a typical year of rainfall.

LEWS1070-B

This regulator is located on Clifton Boulevard at the intersection of Whippoorwill Avenue. The sewer on Clifton is a combined sewer that becomes overloaded with clear water. An overflow pipe connects to the storm sewer that flows north on Whippoorwill. Modeling indicates that that installation of green infrastructure (permeable paving and bioretention) and source control technology on Clifton Boulevard within the LEWS1070 and LEWS1135 drainage area will reduce this overflow to two events in a typical year of rainfall discharging 0.0041 Mgal.

LEWS1110-A (CSO-058)

Most of the flow in this outfall on Edgewater Drive between Roy Drive and Kirtland Avenue is from the separate storm sewer system south of Lake Avenue. To reduce the volume of flow to the regulator at Edgewater Drive, a new 36-inch diameter storm sewer is proposed from Lake Avenue to north of the regulator on Edgewater Drive. The remaining flow to the regulator will consist of a small section of combined sewer on Lake Avenue. Modeling indicates that employing source control and green infrastructure in the area of the combined sewer will reduce this overflow to zero events in a typical year of rainfall.

LEWS1130-A

This location on the northeast corner of Clifton Boulevard and Belle Avenue was a potential overflow location because a manhole cover separating the storm sewer from the combined sewer was missing. Modeling indicated that the sewers did not surcharge suffi-



ciently to create an overflow. The manhole cover was replaced and this location has been removed from the list of overflows.

LEWS1130-B

This location on the north side of Clifton Boulevard at Marlowe Avenue was a potential overflow location because a manhole cover separating the storm sewer from the combined sewer was missing. Modeling indicated that the sewers did not surcharge sufficiently to create an overflow. The manhole cover was replaced and this location has been removed from the list of overflows.

LEWS1130-C

The overflow is located at the southeast corner of Clifton Boulevard and Belle Avenue. The regulator is a weir located on the Belle Avenue combined sewer. Modeling indicates that source control on Warren Road, Onondaga Avenue, St. Charles Avenue, and Belle Avenue south of Detroit Avenue, when coupled with green infrastructure and source control on Belle Avenue north of Detroit Avenue will reduce this overflow to zero events in a typical year of rainfall.

LEWS1135 (CSO-057)

The overflow is located at the interceptor where it crosses Lakewood Park. The proposed technology to bring this overflow into compliance with the permit is green infrastructure on Clifton Boulevard between Nicholson Avenue and Belle Avenue coupled with source control between Clifton Boulevard and Detroit Avenue on Ramona Avenue, Manor Park Avenue, Chase Avenue, Bunts Road, Hathaway Avenue, Geil Avenue, Elbur Avenue and Jackson Avenue. Source control is proposed on Marlowe Avenue between Clifton Boulevard and Madison Avenue, Lincoln Avenue between Clifton Boulevard between Detroit Avenue, and Olivewood Avenue between Clifton Boulevard and Cedarwood Avenue.

Modeling indicates that employing these technologies in the prescribed area will reduce this overflow to four events in a typical year of rainfall discharging a volume of 0.070 Mgal.

LEWS1150 (CSO-056B)

After completion of the sewer separation project on Edgewater Drive between the regulator and Abbieshire Drive, this overflow is no longer discharging combined sewage from Edgewater Drive, Rosalie Avenue, and Abbieshire Drive.

The sewer from the regulator south to Lake Avenue conveys primarily stormwater along with sewage from the sanitary sewer on Lake Avenue. The proposed plan is to remove



the sewage contributed by Lake Avenue by constructing a new 12-inch sanitary sewer in Lake Avenue from Lakeland Avenue east to the vicinity of the combined north/south sewer and redirecting the existing sanitary sewers to the new sanitary sewer thereby removing the direct sewage connection to the combined sewer.

The flow to the regulator will now consist of primarily stormwater flow and overflow from two upstream overflows (LEWS 1150-C and LEWS 1150-D). Two other upstream overflows (LEWS 1150-B and LEWS 1150-E) will be removed.

LEWS1150 -A

The recently completed sewer separation project on Edgewater Drive east of the regulator has turned the former combined sewer overflow into a storm sewer. The regulator has been removed.

LEWS1150 -B

This overflow on Clifton Boulevard at Andrews Avenue consists of a steel pipe suspended in a vault that has a 3-foot long section of pipe with the top half missing. The overflow activates any time the pipe flows more than half full. Source control on St. Charles Avenue, Warren Road, Cook Avenue, and Gladys Avenue between Clifton Boulevard and Detroit Avenue when coupled with green infrastructure on Clifton Boulevard (between Belle Avenue and Cook Avenue), Elmwood Avenue, and Mars Avenue (between Detroit Avenue and Hilliard Road) will allow this overflow to be removed either through banding of the opening or replacement of the pipe in the vault, thus eliminating the overflows.

LEWS1150 -C

This overflow is located at the intersection of Elmwood Avenue and Detroit Avenue. The sewer on Elmwood is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) on Elmwood along with source control on Elmwood will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.044 MGal.

LEWS1150 -D

This overflow is located at the intersection of Mars Avenue and Detroit Avenue. The sewer on Mars is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet



weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) on Mars along with source control on Mars will reduce this overflow to one event in a typical year of rainfall discharging a volume of 0.009 MGal.

LEWS1150 -E

This overflow is located at the intersection of Victoria Avenue and Hilliard Road. The sewer on Victoria has combined flow that drops through a missing invert plate in a manhole at Hilliard Road during dry weather. Wet weather flow leaps over the missing plate to the storm sewer on the effluent side of the manhole. Due to the nature of the regulator, separation is proposed for Victoria Avenue south of Hilliard Road. Separation will also require removal of any clear water sources emanating from homes on this section of Victoria Avenue. The separation will allow the overflow to be closed.

LEWS1155 (CSO-056A)

After the sewer separation project on Edgewater Drive from the outfall west to Cliffdale Avenue, the outfall discharges only stormwater and is no longer a CSO. The 8-inch sewer connecting CSO-056A to CSO-056B has been bulkheaded hydraulically separating the two outfalls.

LEWS1180-A

This overflow is at the intersection of Clifton Boulevard and Lakeland Avenue. The overflow is on a shelf with a weir that can allow combined sewage to overflow to the storm sewer below. The primary cause of overflow in this sewer is backup from the sewer on Summit Avenue, the next street to the west that takes flow from Clifton Boulevard and an area south of Detroit Avenue between Arthur Avenue and Orchard Grove Avenue. Source control is proposed on:

- Arthur Avenue (between Detroit Avenue and Hilliard Road)
- Lakeland Avenue (between Detroit Avenue and Hilliard Road)
- Westwood Avenue (between Detroit Avenue and Hilliard Road)
- Rosewood Avenue (between Detroit Avenue and Hilliard Road)
- Orchard Grove (between Detroit and Hilliard Road)
- Andrews Avenue (between Clifton Boulevard and Detroit Avenue)
- French Avenue (between Clifton Boulevard and Andrews Lane)
- Virginia Avenue (between Clifton Boulevard and Andrews Lane)
- Lakeland Avenue (between Clifton Boulevard and Detroit Avenue)
- Summit Avenue (between the interceptor and Detroit Avenue)



Green infrastructure (permeable pavement and bioretention) is proposed on Clifton Boulevard between Andrews Avenue and Summit Avenue.

Modeling indicates that implementation of these technologies in the delineated areas will reduce the overflows to zero events in a typical year of rainfall.

LEWS1195-A

The overflow is located on the interceptor at Summit Avenue and consists of a pipe higher in the manhole that discharges to the LEWS1195 outfall. Technology employed to control LEWS1035 (CSO-059), the High Rate Treatment plant, and local sewer source control/green infrastructure will lower the hydraulic grade line in the interceptor to reduce overflows to zero events in a typical year of rainfall.

LEWS1210-A

The overflow is located at the north end of Forest Cliff Drive. Modeling indicates that source control on the local sewers tributary to the overflow will eliminate activation of the overflow and allow it to be bulkheaded.

LEWS1215-A

The overflow is located on Erie Cliff Drive at the interceptor. Modeling indicates that green infrastructure technology coupled with source control on the local sewers tributary to the overflow will reduce the overflows to zero events in a typical year of rainfall.

LEWS1220-A

The overflow is located at the north end of Maple Cliff Drive. Modeling indicates that green infrastructure technology coupled with source control on the local sewers tributary to the overflow will reduce the overflows to zero events in a typical year of rainfall.

LEWS1225 (CSO-055)

The overflow is located on the local sewer adjacent to the interceptor on Edgewater Drive between Kenneth Drive and Maple Cliff Drive. This outfall will become a stormwater outfall after doing a sewer separation of the combined system on Westlake Avenue. A separate sanitary sewer would be constructed on Westlake Avenue from Detroit Avenue north to Clifton Boulevard, west on Clifton Boulevard to Hall Avenue, north on Hall Avenue to Lake Avenue, east on Lake Avenue to Maple Cliff Drive, then north on Maple Cliff Drive to the interceptor. As part of the project, a new sanitary sewer will be constructed on Clifton Boulevard and Lake Avenue to convert the existing combined sewer to a storm sewer. After completion of the project, the LEWS1225 outfall will discharge



only stormwater. Note that all sewer separation projects require source control to eliminate clear water connections to the new sanitary sewer.

LEWS1285-A

This regulator is located on Edgewater Drive between Webb Road and Kenneth Drive and is just downstream of another regulator. This location is a backup or secondary overflow to the primary overflow located at LEWS1295-A and has a low weir wall that directs overflow from primary overflow to the interceptor. The control technology employed to deactivate LEWS1295-A will also reduce the overflows to zero events in a typical year of rainfall.

LEWS1295-A

This regulator is located on Lake Avenue between Webb Road and Kenneth Lane and is immediately upstream of overflow LEWS1285-A. The overflow is regulated by a low weir wall with base flow conveyed to the sanitary sewer on Lake Road through an 8-inch outlet on the west side of the manhole and the overflow conveyed to LEWS1285-A through a 24-inch combined to the north. Modeling indicates that green infrastructure on Clifton Boulevard between Edwards Avenue and the Granger Avenue will reduce the overflows to zero events in a typical year of rainfall.

There is a storm-to-storm connection between the two storm sewers on Clifton Boulevard at Granger Avenue. The connecting pipe is 6.8-feet higher than the southern storm sewer. This overflow pipe should be plugged to alleviate the chance of overloading the Lake Avenue local sewer at LEWS1295-A.

The last modification is to redirect the south storm sewer on Lake Avenue around the combined sewer regulator to the storm sewer on the north side of Lake Road just west of the regulator. This modification will remove any storm sewer system flow to the regulator.

LEWS1295-B

The overflow is located at the intersection of Lake Avenue and Webb Road. Green infrastructure and source control on Clifton Boulevard between Hall Avenue and Webb Road will reduce the overflows to zero events in a typical year of rainfall.

LEWS1295-C

The overflow is located on the combined sewer on the south side of Clifton at the intersection with Edwards. The overflow is located 7.4 feet above the bottom of the manhole. Green infrastructure and source control on Clifton Boulevard between Summit Avenue



and Edwards Avenue as well as Hall Avenue south of Clifton Boulevard will reduce the overflows to zero events in a typical year of rainfall.

WWTP Outfall (CSO-002)

The regulator for this outfall is located at the end of West Clifton Boulevard on the Rocky River at the head of the aerial influent sewer to the WWTP. While the regulator is at this location, the discharge from the regulator is at the WWTP outfall located off the end of Webb Road in Lake Erie. The technology employed to reduce this overflow to zero events in a typical year of rainfall is High Rate Treatment at the WWTP. Refer to the technical memorandum in Attachment E for the basis of design of the HRT.

RRES1140 (CSO-0054)

This overflow at the intersection of Scenic Street and Graber Alley has been eliminated by construction of the West End CSO Elimination Project discussed in Paragraph 8.3.2.

RRES1145-A, RRES-C through RRES1145-H

These overflows are all located on West Clifton Boulevard between Riverside Drive and Detroit Avenue. They are located on the local sewers on the east and west side of the street. The overflows are longitudinal weir walls that separate the storm sewer and the sanitary sewer in each manhole. Source control along this section of West Clifton Boulevard will reduce these overflows to zero events in a typical year of rainfall.

RRES1145-I

This overflow is located at the intersection of Clifton Place and Detroit Avenue. The sewer on Clifton Place is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) on Clifton Place along with source control on Clifton Place will reduce this overflow to zero events in a typical year of rainfall.

RRES1145-J

This overflow is located at the intersection of Rockway Avenue and Detroit Avenue. The sewer on Rockway is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow through a hydrobrake to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that after installation of green infrastructure on Rockway, the hydrobrake is causing overflow events than if the



hydrobrake was not present. The initial hydraulic condition for the hydrobrake is no longer present with the reduction of flow in the sanitary sewer on Detroit Avenue due to the proposed control technologies upstream of this intersection. Modeling calculates the improvements will reduce this overflow to zero events in a typical year of rainfall.

RRES1145-K

This location consists of two cascading half pipe overflows in a single manhole which is located at 1421 Spring Garden Avenue about 250 feet south of Detroit Avenue. This same manhole serves as a transition from an over/under sewer from the south where the sanitary sewer is located over the storm sewer, to an over/under sewer to the north where the storm sewer is located over the sanitary sewer.

The upper sanitary flow from the south can overflow the half pipe into the half pipe storm sewer below it. The half pipe storm sewer can overflow to the sanitary sewer at the bottom of the manhole which exits to the north. Should the lowest sanitary sewer surcharge, the combined sewage would be discharged to the storm sewer exiting to the north that is located immediately above the lowest sanitary sewer. Modeling indicates that installation of green infrastructure along with source control on Spring Garden will reduce this overflow to five events in a typical year of rainfall discharging 0.231 MGal.

Further analyses are required to bring this overflow in compliance with the federal CSO policy. The City of Lakewood intends to explore other alternatives within Phase 2.

RRES1145-L

This overflow is located at the intersection of Larchmont Avenue and Detroit Avenue. The sewer on Larchmont is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure (permeable paving and bioretention) on Larchmont along with source control on Larchmont will reduce this overflow to two events in a typical year of rainfall discharging 0.173 MGal.

RRES1145-M

This overflow is located at the intersection of Wagar Avenue and Detroit Avenue. The sewer on Wagar is a combined sewer that connects to the over/under sewer on Detroit Avenue. A regulator directs dry weather flow to the lower sanitary sewer on Detroit. Wet weather flow backs up in the regulator until flow is discharged through an upper pipe to the storm sewer. Modeling indicates that installation of green infrastructure



(permeable paving and bioretention) on Wagar along with source control on Wagar will reduce this overflow to one event in a typical year of rainfall discharging 0.122 MGal.

RRES1145-N

This overflow is located on West Clifton Boulevard just south of the Norfolk Southern Railroad underpass. The overflow manhole is in the center of the pavement. The sanitary sewer is a half-pipe running through the storm manhole. A flow depth in excess of a half pipe will overflow into the storm. Modeling indicates that source control along this section of West Clifton Boulevard will reduce these overflows to zero events in a typical year of rainfall. Upon completion of source control technology, the sanitary sewer should be enclosed to prevent stormwater intrusion into the sanitary system.

RRES1145-O

This overflow is located on West Clifton Boulevard just north of the Norfolk Southern Railroad underpass. The overflow manhole is in the center of the pavement. The manhole is divided in two sections by a brick wall; the left chamber is on the interceptor and the right chamber is on the storm sewer. The dividing wall extends to within 6.5 feet of the manhole cover. For this overflow to activate, the interceptor would need to surcharge to a depth of 23.5 feet. Modeling indicates that the interceptor at this location does not surcharge to that depth in a typical year of rainfall.

RRES1145-P, RRES-S through RRES1145-V

These overflows are all located on West Clifton Boulevard between Detroit Avenue and Clifton Boulevard. They are located on the local sewers on the east and west side of the street. The overflows are longitudinal weir walls that separate the storm sewer and the sanitary sewer in each manhole. Modeling indicates that source control along this section of West Clifton Boulevard will reduce these overflows to zero events in a typical year of rainfall.

RRES1145-R

The overflow manhole is located on West Clifton Boulevard in the tree lawn near Horace Mann Elementary School. The regulator is an inside drop connection using a tee connection to the sanitary sewer. The tee has an open top that could allow the sanitary sewer to overflow into the storm sewer that is in the same manhole. Source control along this section of West Clifton Boulevard will reduce these overflows to zero events in a typical year of rainfall.



RRES1145-W

This regulator is located at the southwest corner of West Clifton Boulevard and Clifton Boulevard. The sanitary sewer is separated from the overflow by a low weir wall. Modeling indicates that source control along this section of West Clifton Boulevard will reduce these overflows to zero events in a typical year of rainfall.

RRES1160-A

This overflow is located at the intersection of Olive Avenue and Hilliard Road. Modeling indicates that employing green infrastructure along Olive Avenue coupled with reconstruction of the regulator to have two pipes leaving (one to direct dry weather flow to the sanitary sewer and one to direct wet weather flow to the storm sewer) will reduce these overflows to zero events in a typical year of rainfall.

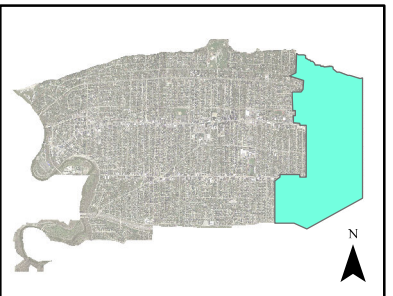
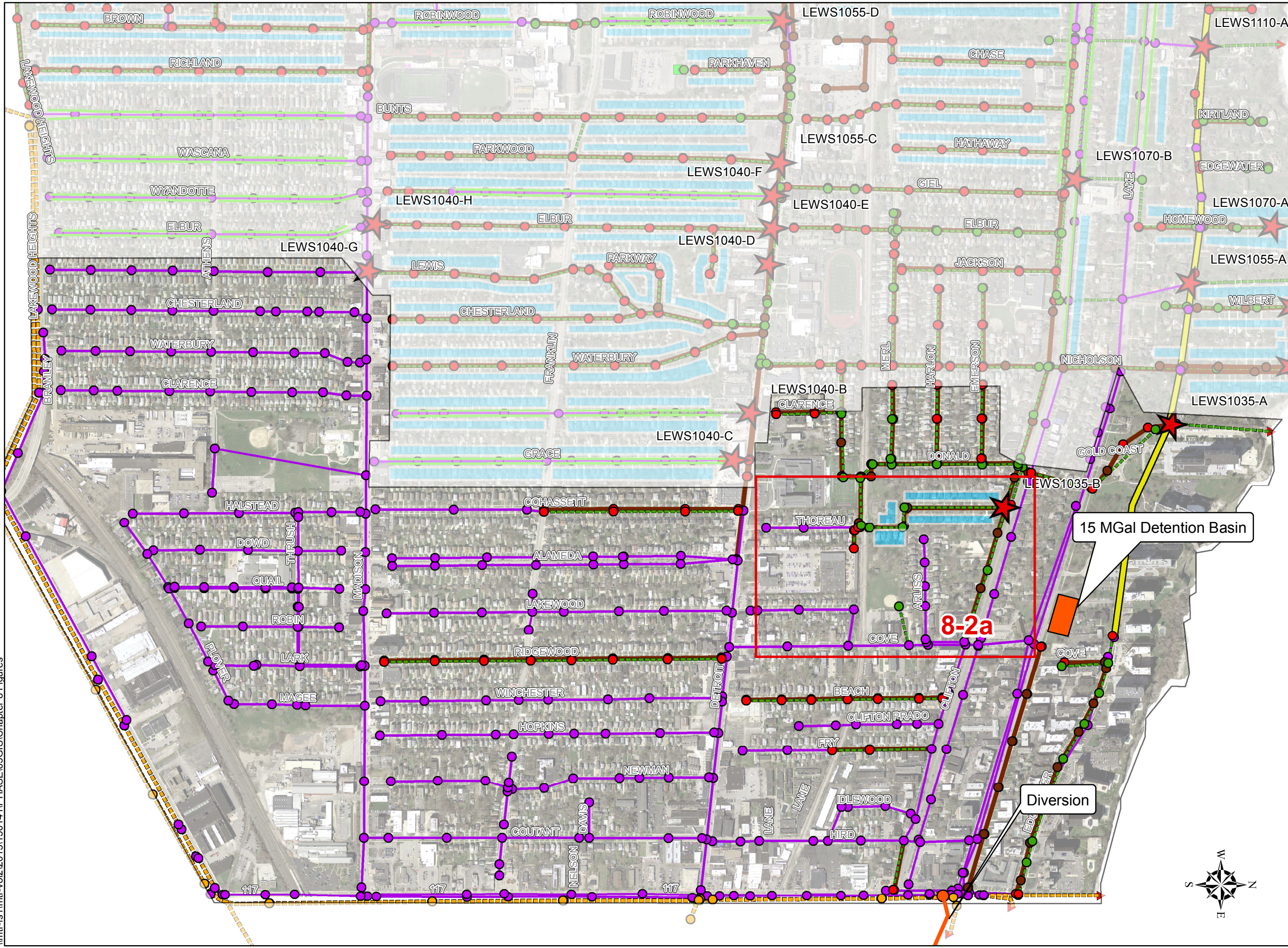
RRES1165-S (CSO-052)

There are three outfalls from this intersection. The northern brick storm sewer outfall is designated RRES1160. The middle steel pipe storm sewer outfall is designated 1165-N and is a backup outfall should RRES1160 become unserviceable. The southern steel pipe storm sewer in RRES1165-S and the overflow is connected to this pipe. Modeling indicates source control and green infrastructure along the sewers tributary to this outfall will reduce these overflows to zero events in a typical year of rainfall.

RRWS1200 (CSO-053)

Construction of the West End CSO Elimination Project has eliminated all flow from Lakewood sewers to this overflow. The remaining flow to this location consists of a small pump station from the Cleveland Metroparks Rocky River Reservation and a small area of the City of Rocky River serving approximately 104 homes. The Rocky River sewers in this area were recently rehabilitated and overflows, if they occur, will be the result of flow from the City of Rocky River. The City of Rocky River has reported that approximately five properties require additional remediation work to remove clean water from the sanitary sewer that is occurring from driveway drains and window well drains. This information is reported annually in the City of Lakewood's Satellite Sewer Discharge Control Plan.

\\mtr-fs\\mtr-vol2015150141\\PHASE\\65GIS\\Chapter 8 Figures



Legend

Source Control

Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

Overflow site

Outfalls

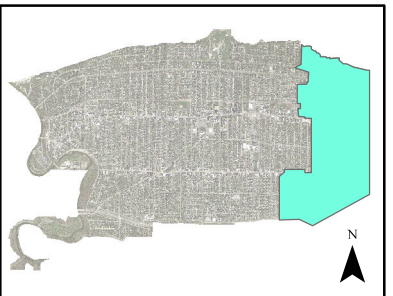
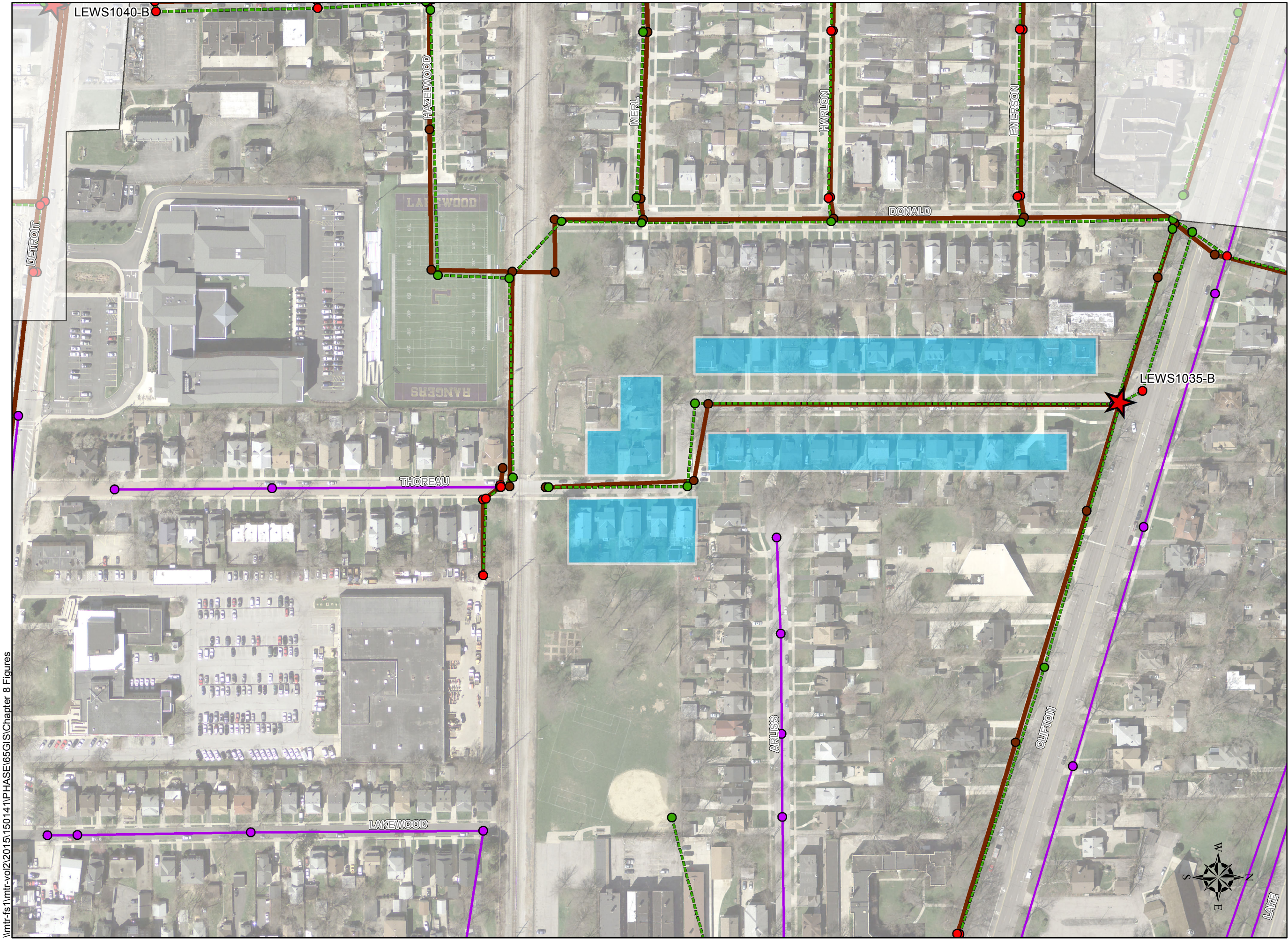
Sewer Type

- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.1 0.2 Miles



LEWS1035
Figure 8-2



Legend

- Source Control
- Green Infrastructure

Manhole Type

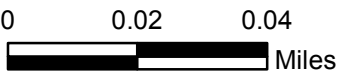
- Combined
- Sanitary
- Storm
- Over/Under
- NEORS



- Outfalls

Sewer Type

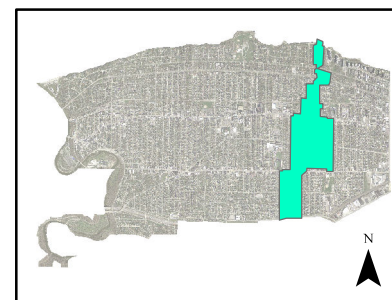
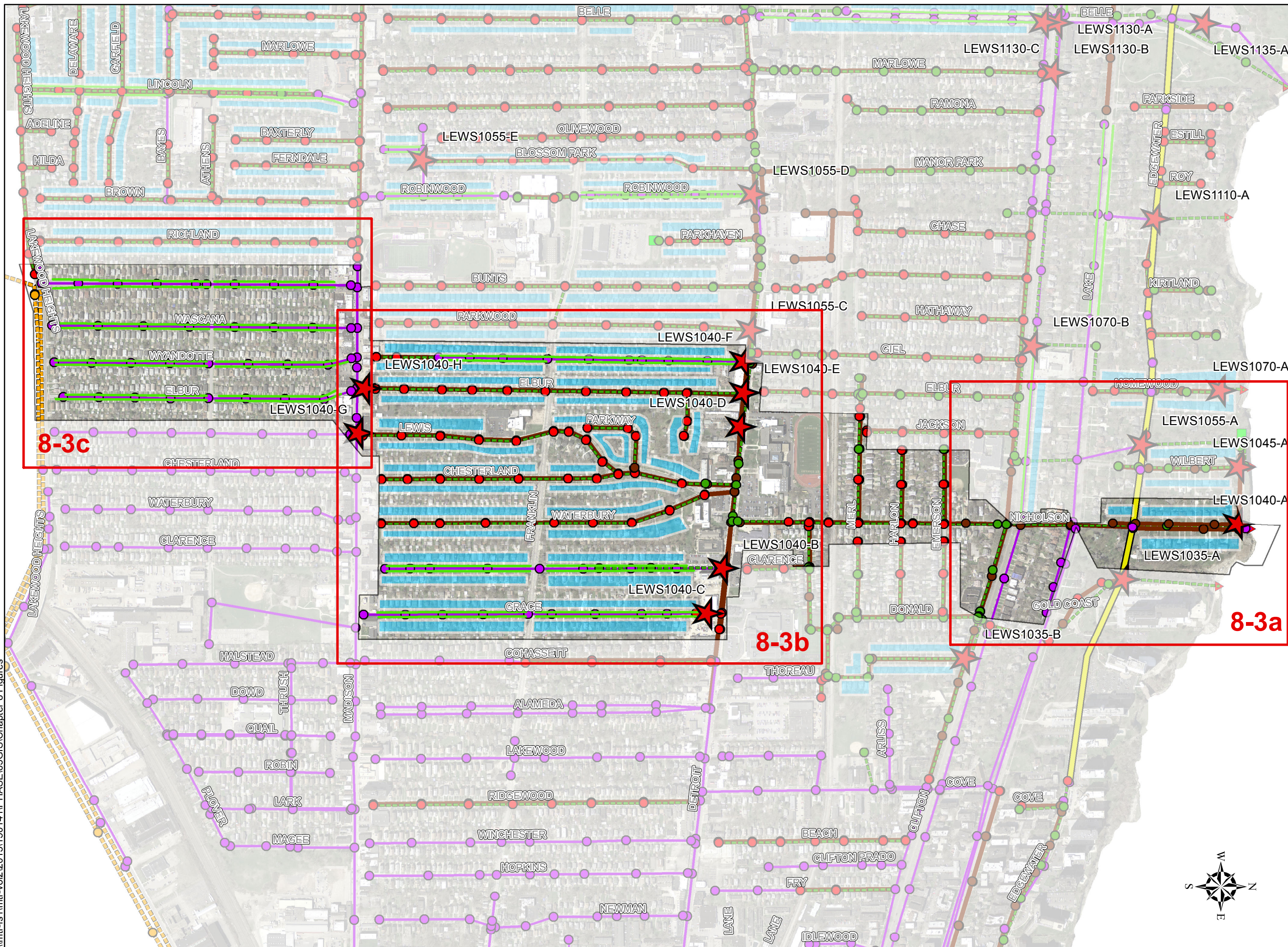
- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs



LEWS1035
Figure 8-2a

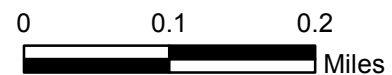
\\mtr-fs\mtr-vol2\150150141\PHASE\65GIS\Chapter 8 Figures

\\mtr-fs\1\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



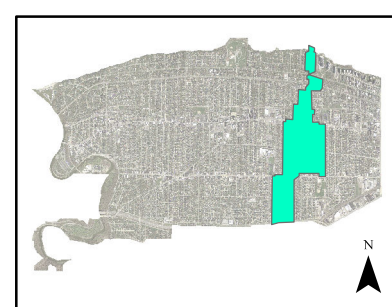
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

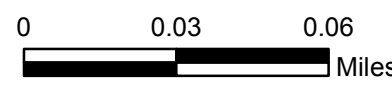


LEWS1040
Figure 8-3

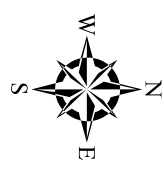
\\mtr-fs1\mtr-vol2\2015\150141\PHASE\65\GIS\Chapter 8 Figures



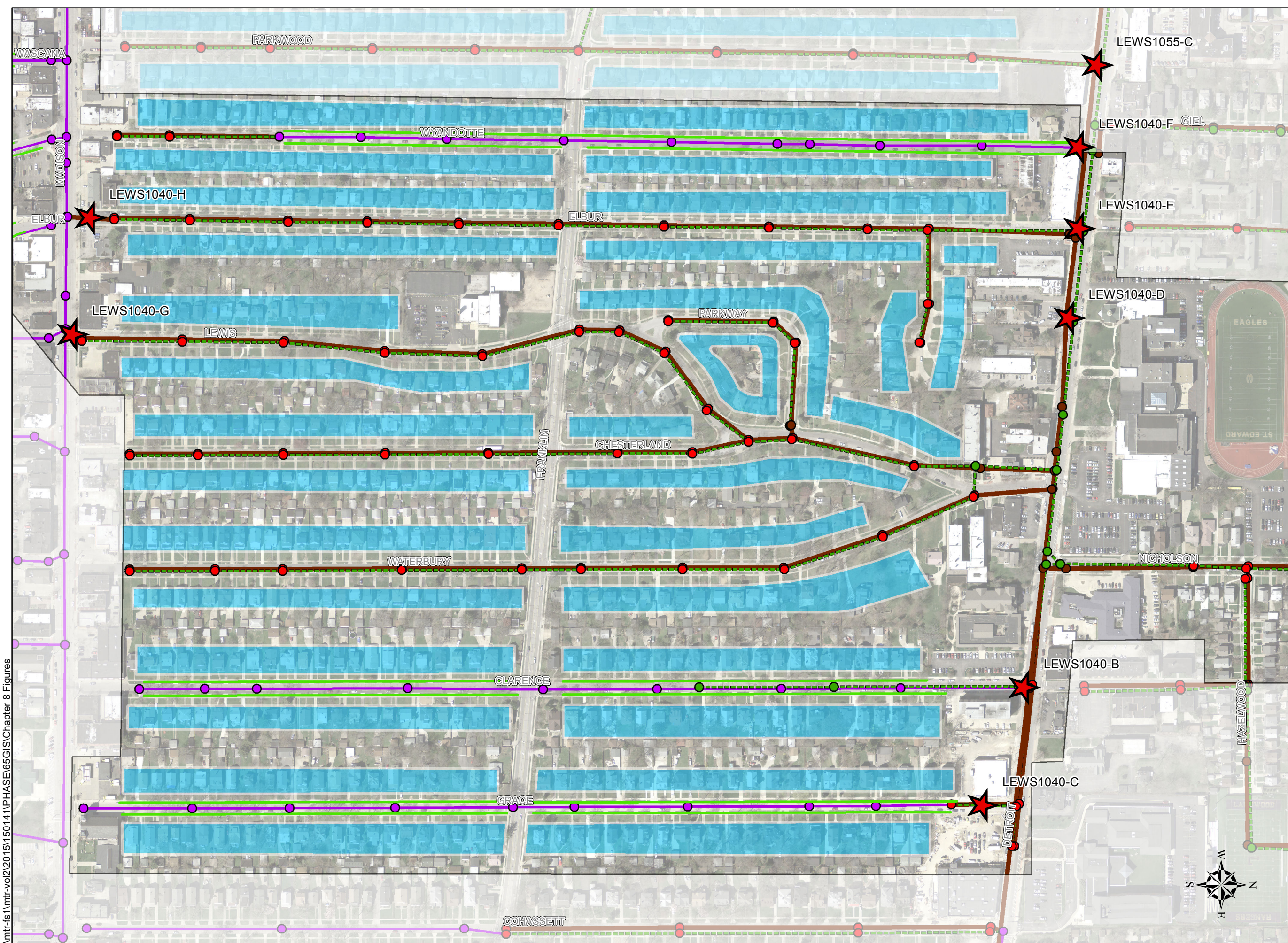
- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

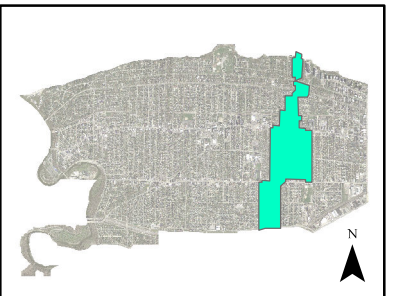


LEWS1040
Figure 8-3a



\\mtr-fs\1\mtr-vol2\2015\15014\1\PHASE\65\GIS\Chapter 8 Figures





0 0.04 0.08 Miles

CLEAN WATER LAKEWOOD

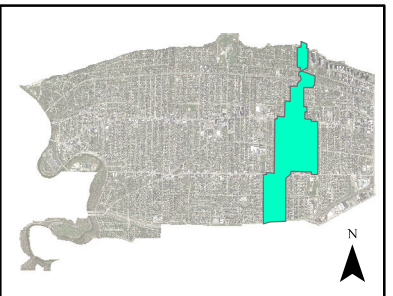
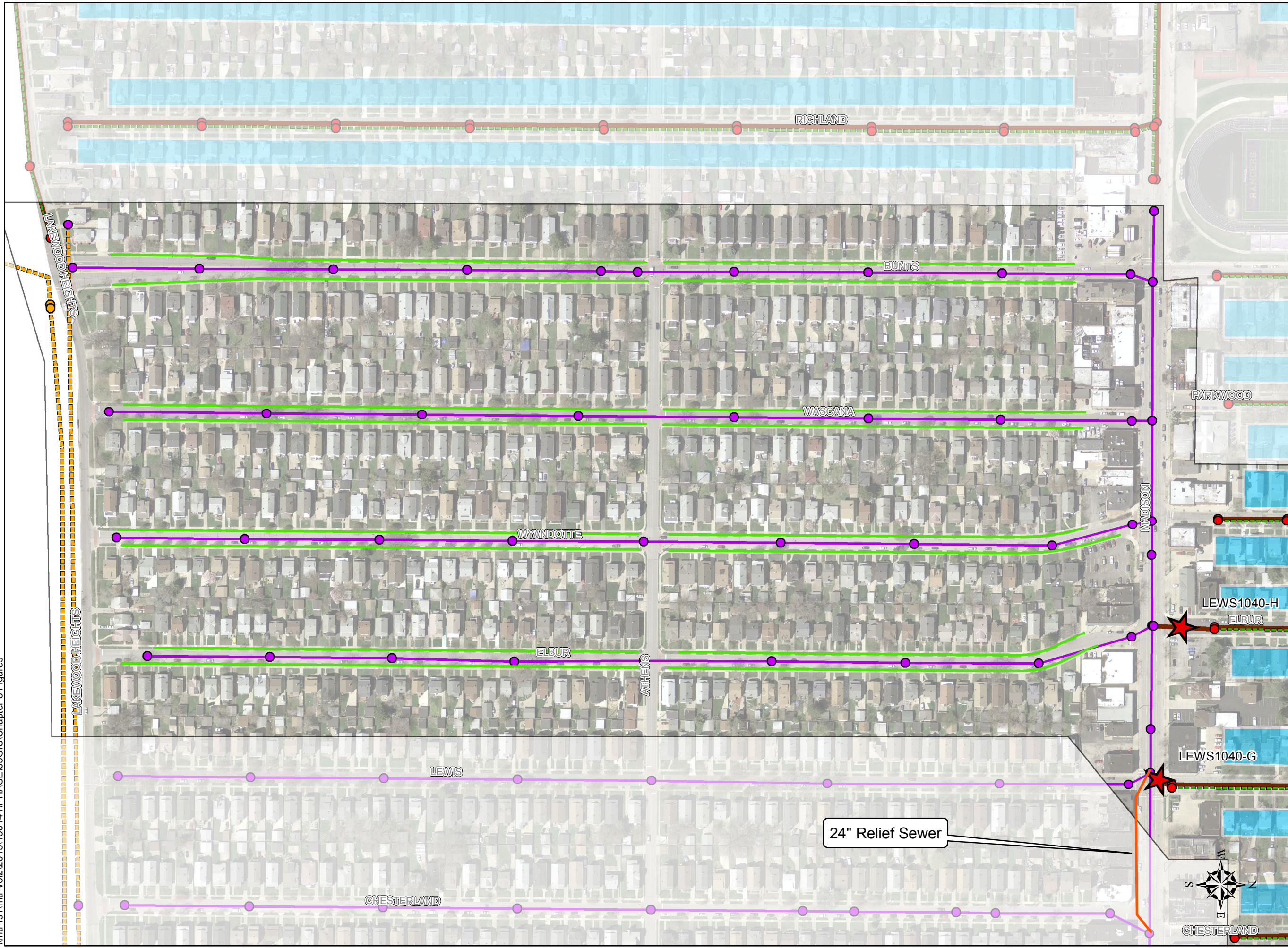


Rebuilding the Pipeline for Our Future

CT Consultants
engineers | architects | planners

LEWS1040
Figure 8-3b

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

0 0.03 0.06 Miles

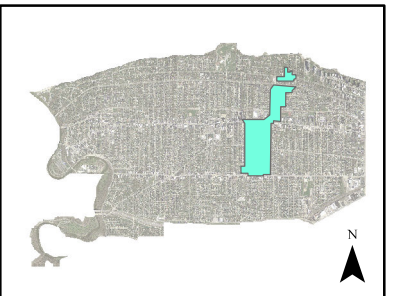
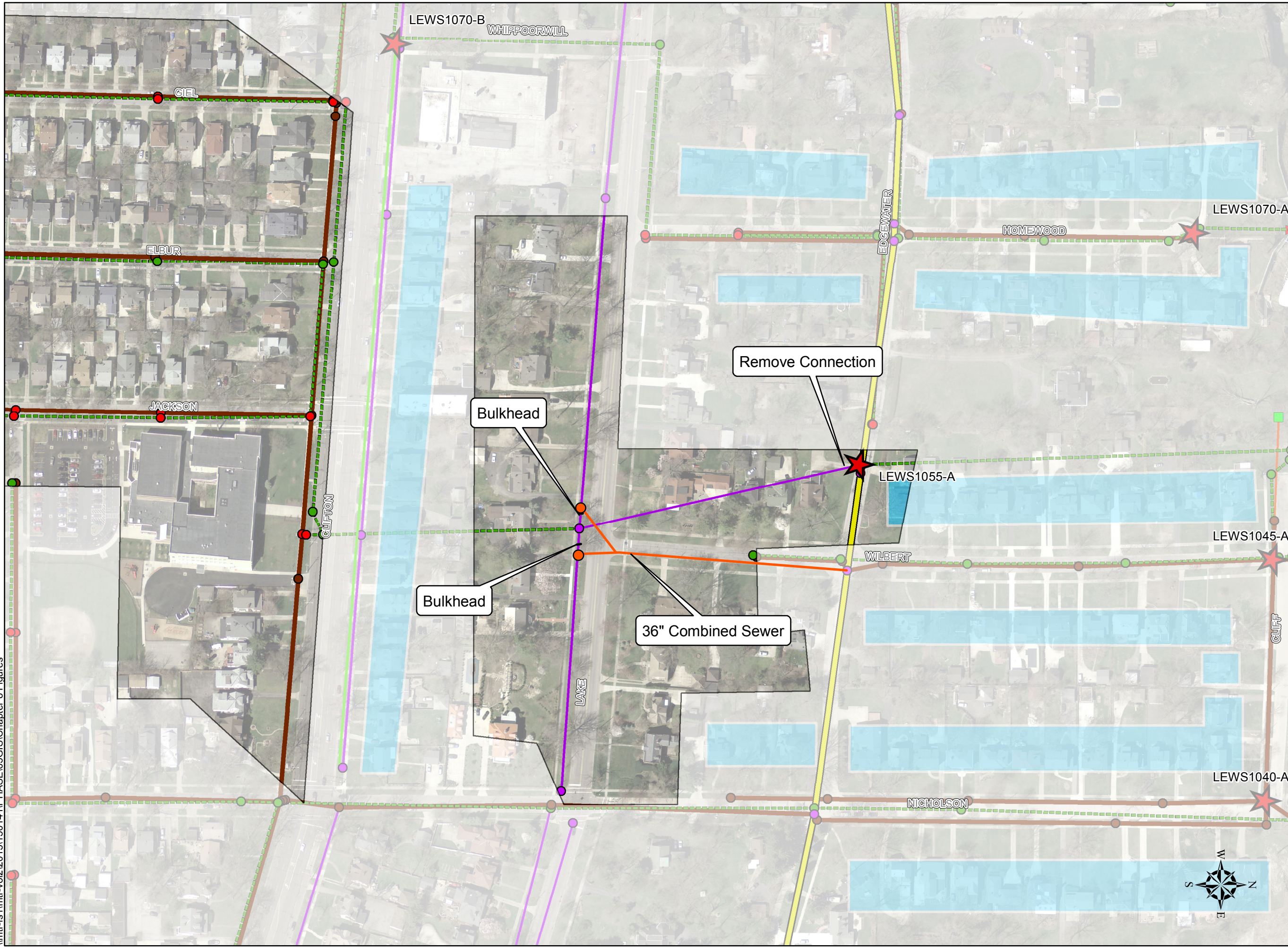
CLEAN WATER
LAKEWOOD

Rebuilding the Pipeline for Our Future

CT Consultants
engineers | architects | planners

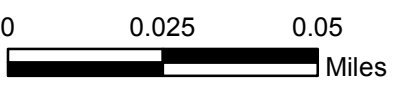
LEWS1040
Figure 8-3c

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



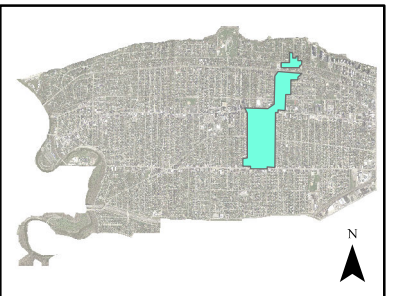
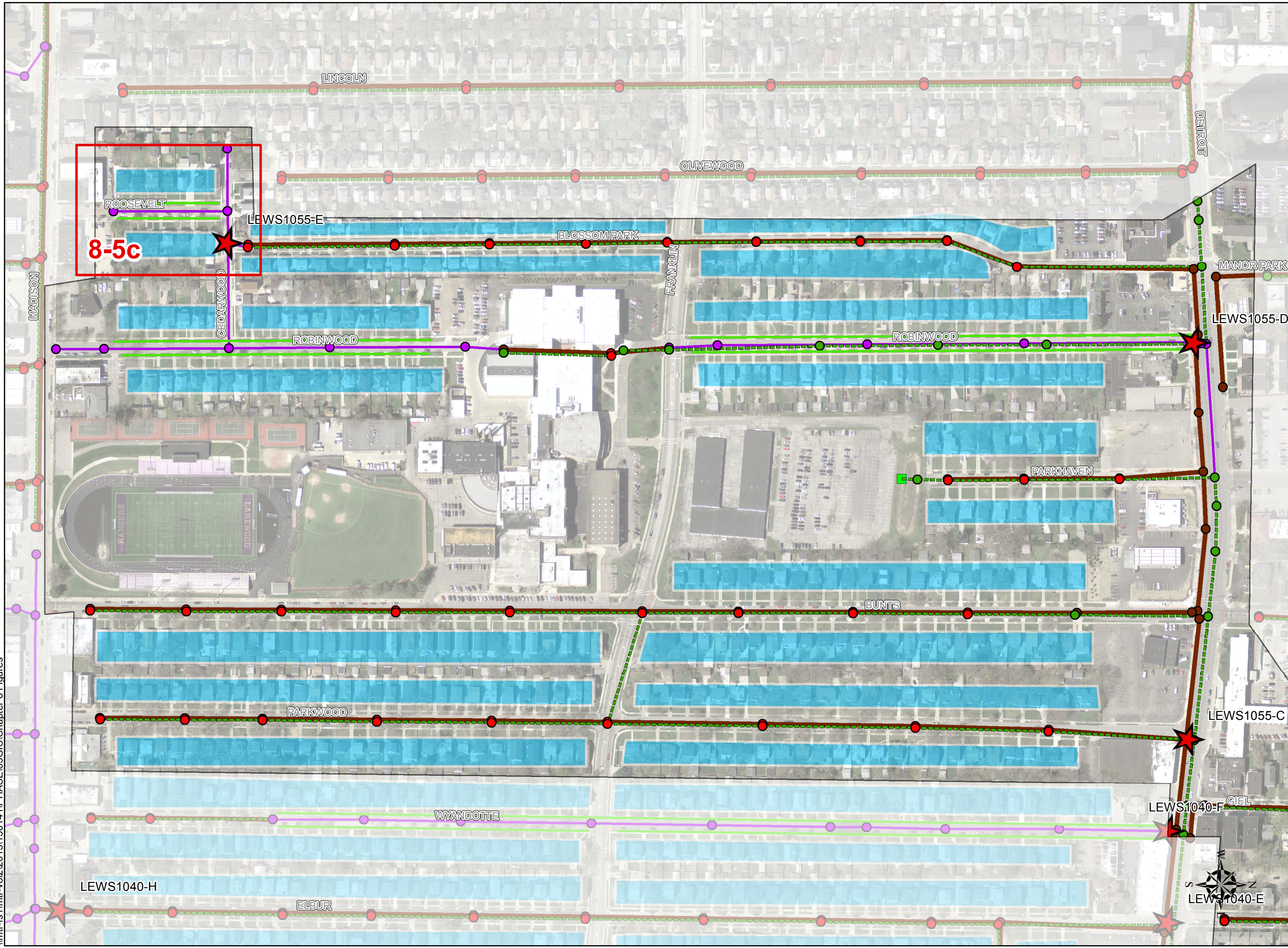
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



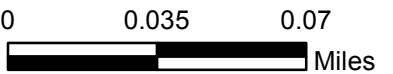
LEWS1055
Figure 8-5a

\\mtr-fs1\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



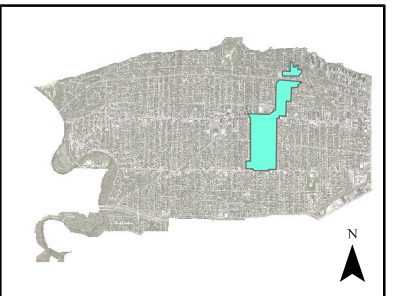
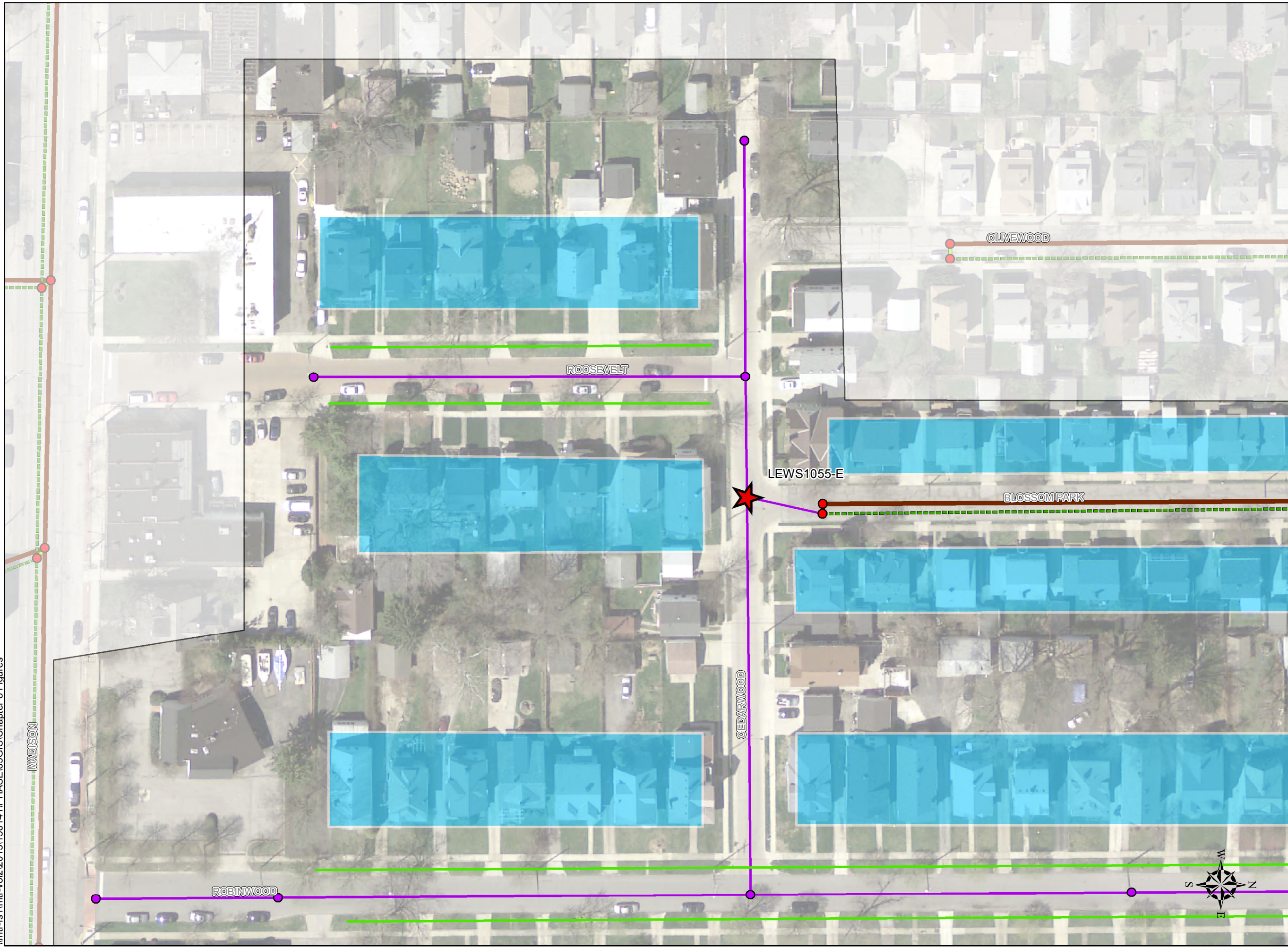
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



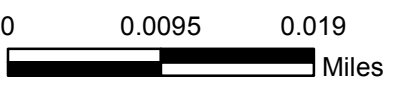
LEWS1055
Figure 8-5b

\\mtr-fs\mtr-vol2\2015\150141\PHASE\65\GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



CLEAN WATER
LAKEWOOD

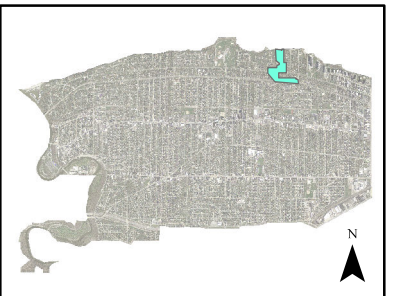
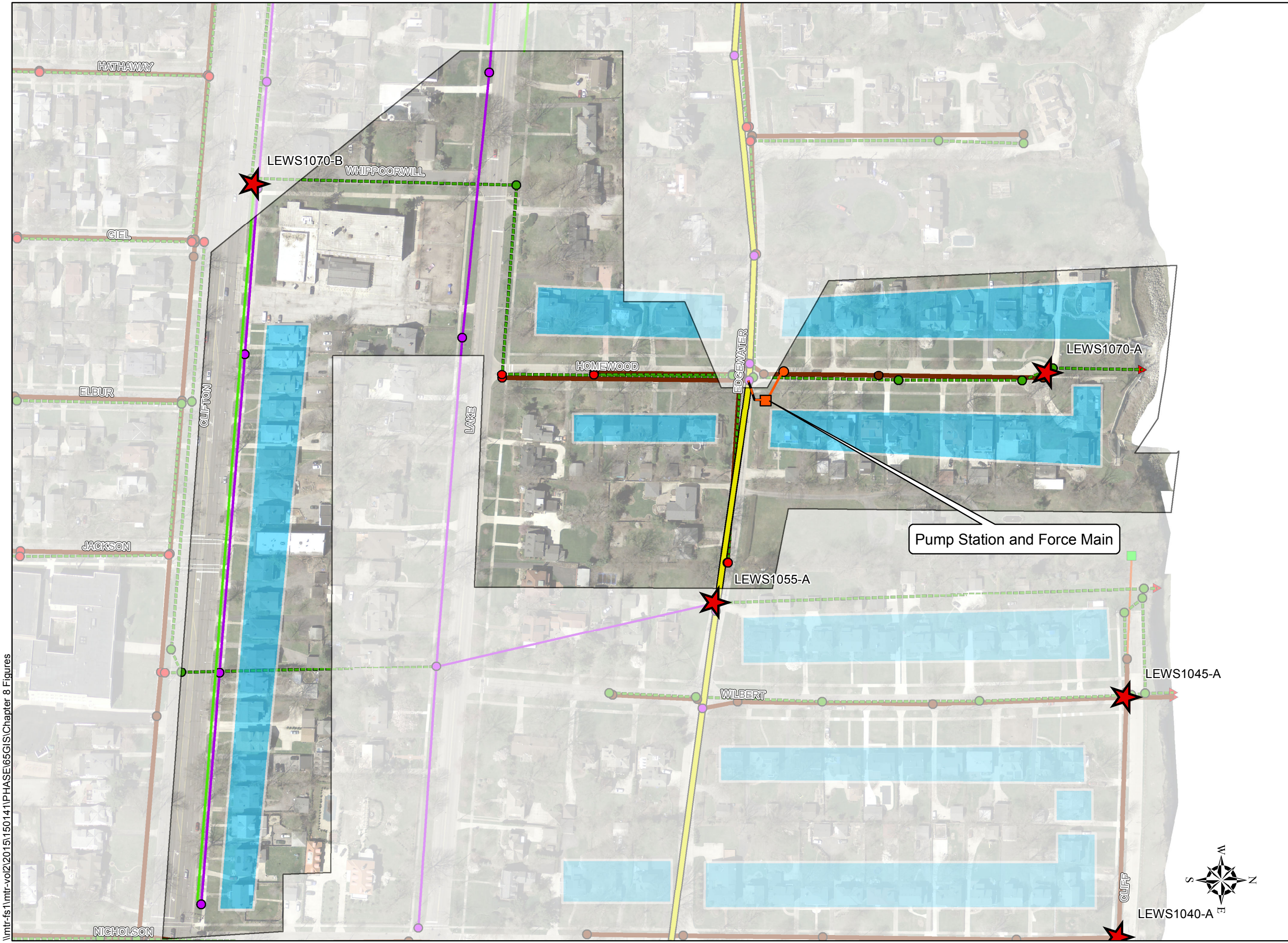


Rebuilding the Pipeline for Our Future



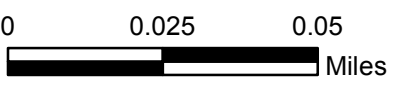
LEWS1055
Figure 8-5c

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



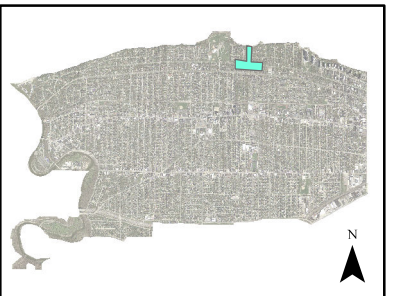
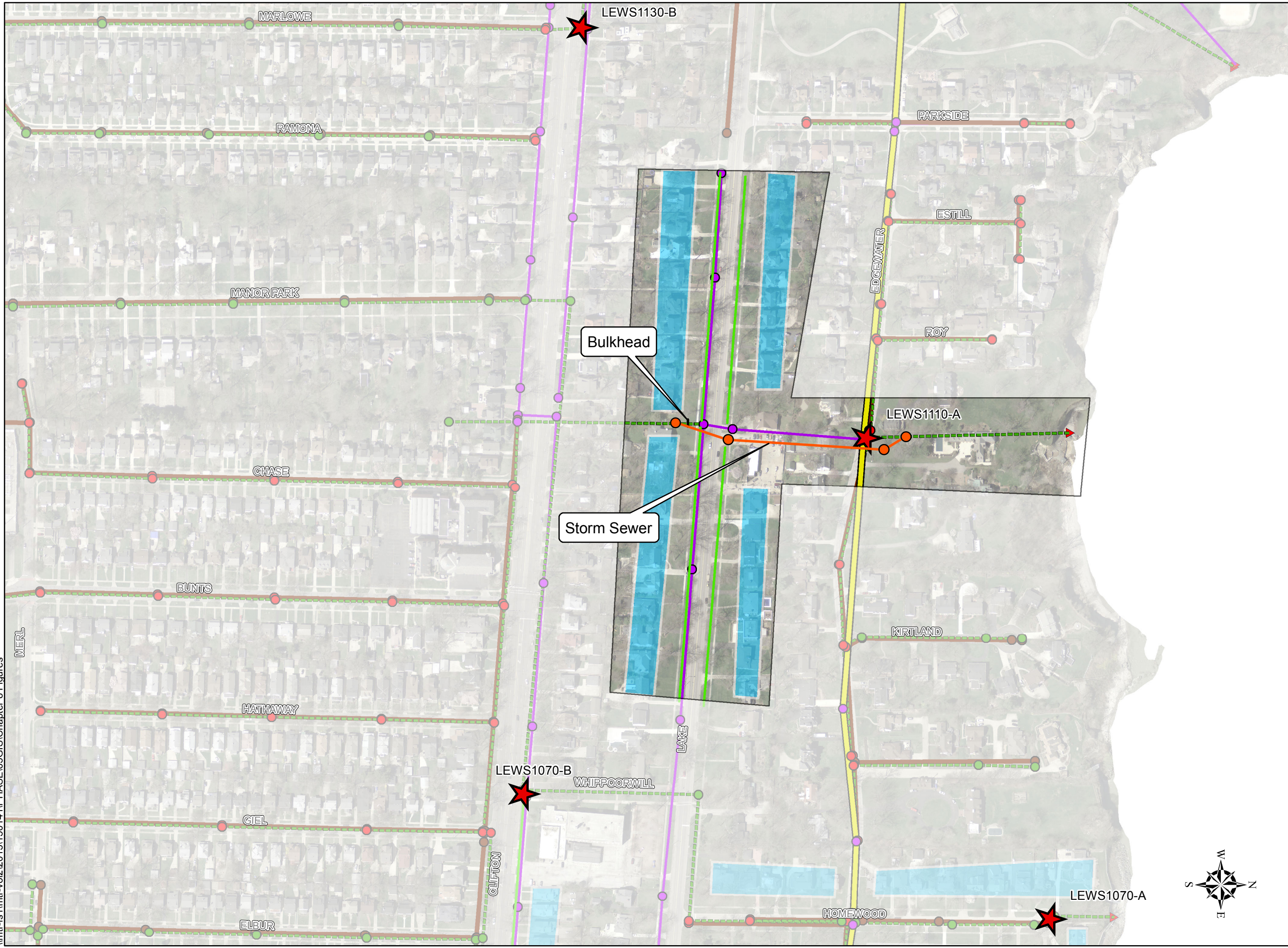
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



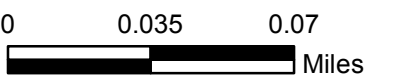
LEWS1070
Figure 8-6

\\mtr-fs1\mtr-vol2\2015\15014\1\PHASE\65\GIS\Chapter 8 Figures



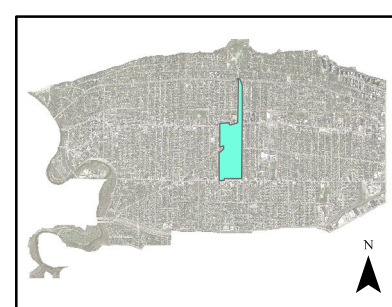
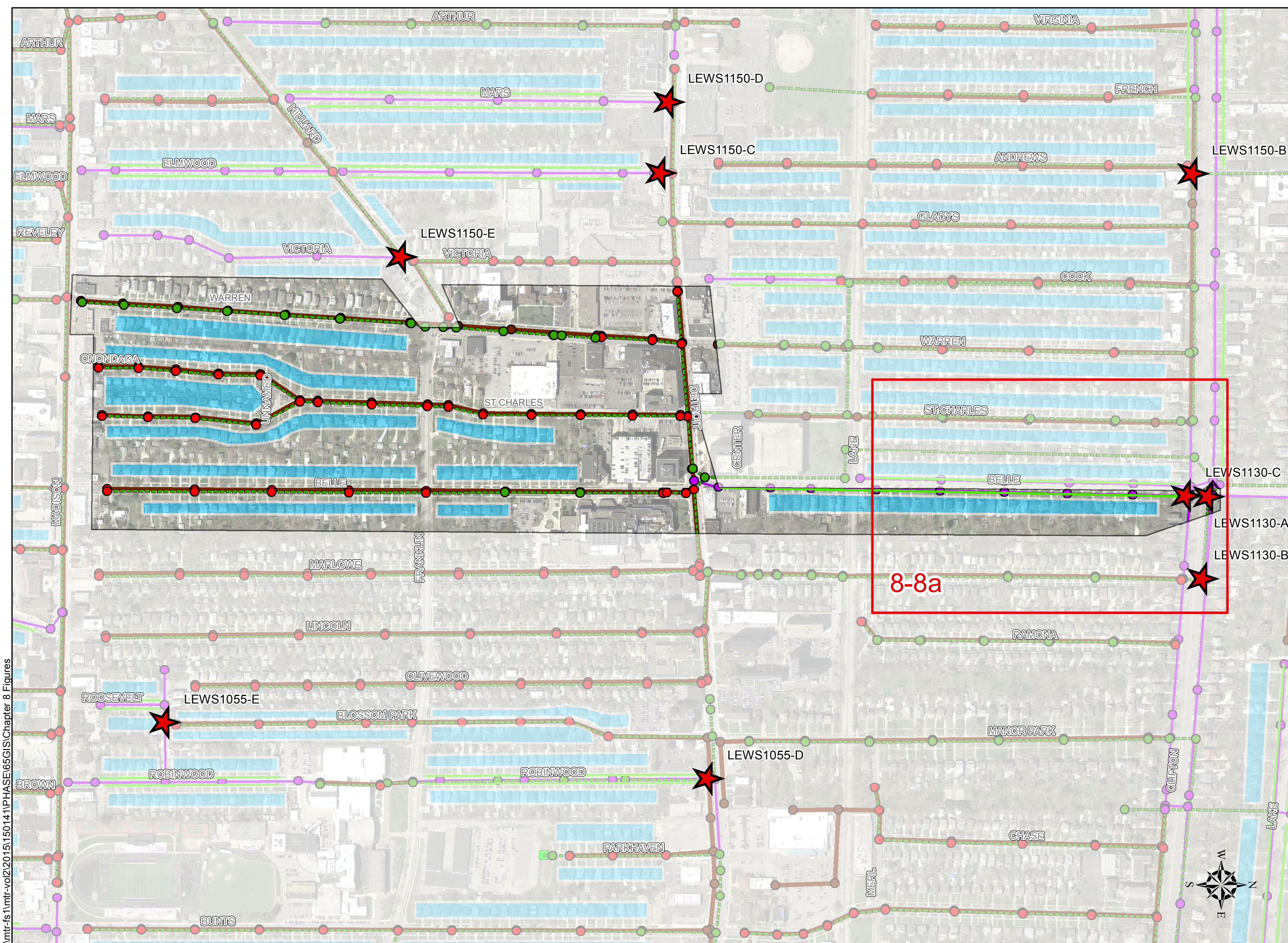
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



LEWS1110
Figure 8-7

\\mtr-fs1\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



Legend

Source Control

Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORSD

Overflow site

Sewer Type

- Combined
- INT
- NEORSD
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.06 0.12 Miles

CLEAN WATER LAKEWOOD

Rebuilding the Pipeline for Our Future

CT Consultants
engineers | architects | planners

LEWS1130
Figure 8-8

\\mtr-fs\mtr-vol2015\150141\PHASE\65GIS\Chapter 8 Figures

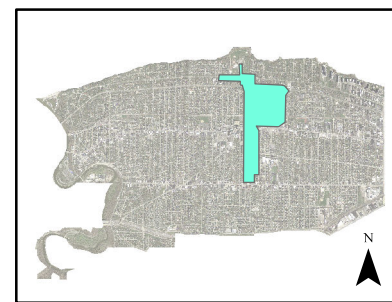


- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

0 0.025 0.05
Miles

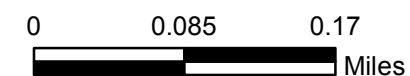


LEWS1130
Figure 8-8a

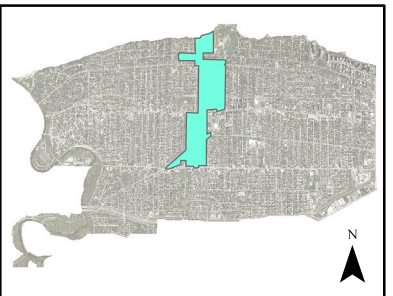
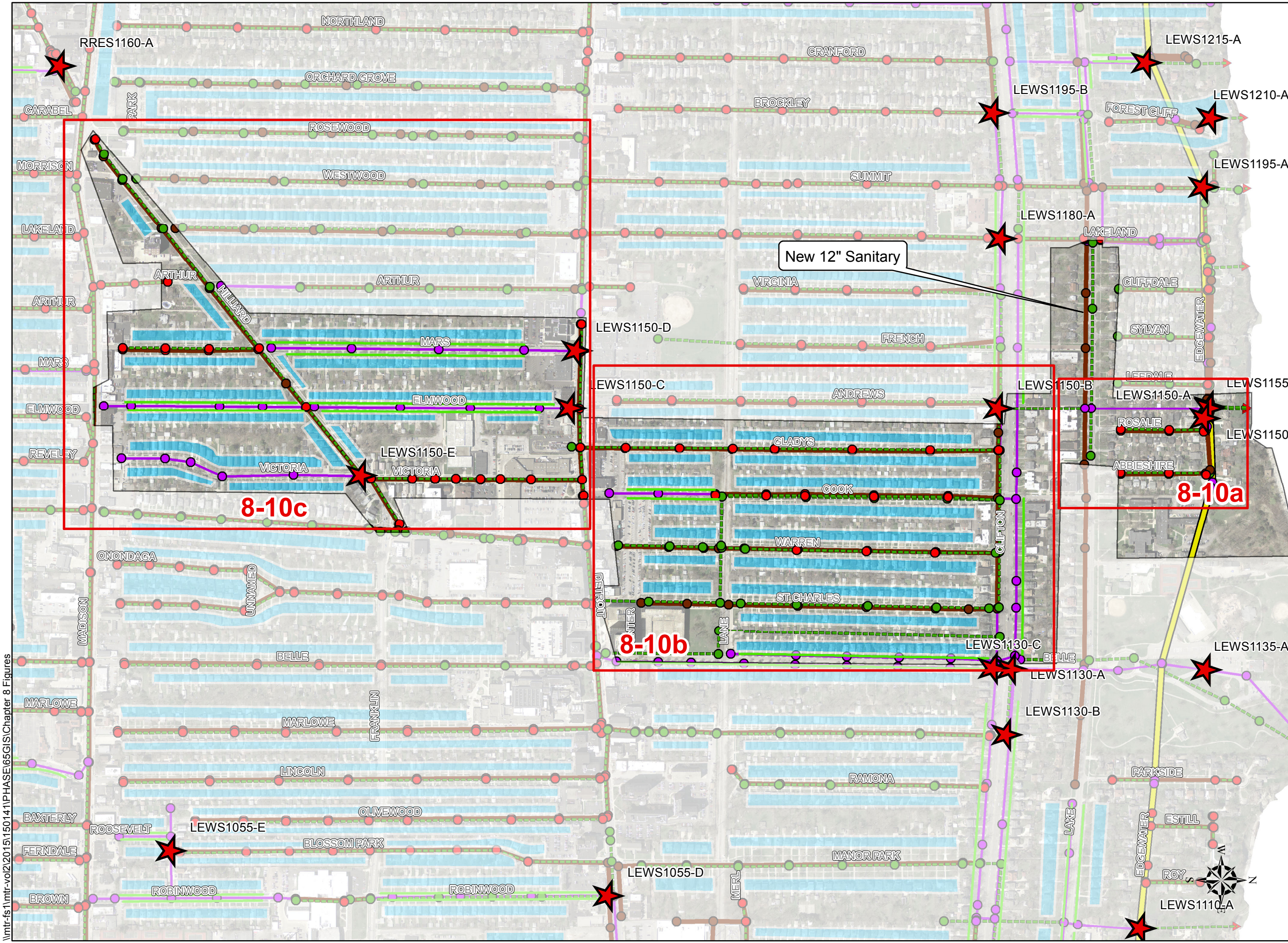


Legend

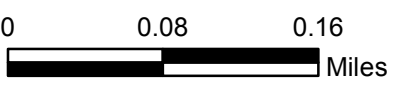
-  Source Control
-  Green Infrastructure
- Manhole Type**
-  Combined
-  Sanitary
-  Storm
-  Over/Under
-  NEORS
-  Overflow site
-  Outfalls
- Sewer Type**
-  Combined
-  INT
-  NEORS
-  Sanitary
-  Storm
-  WWTP
-  Orifices
-  Pumps
-  Weirs



LEWS1135
Figure 8-9



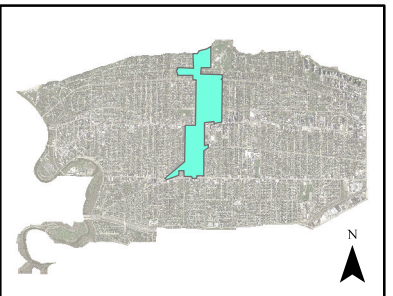
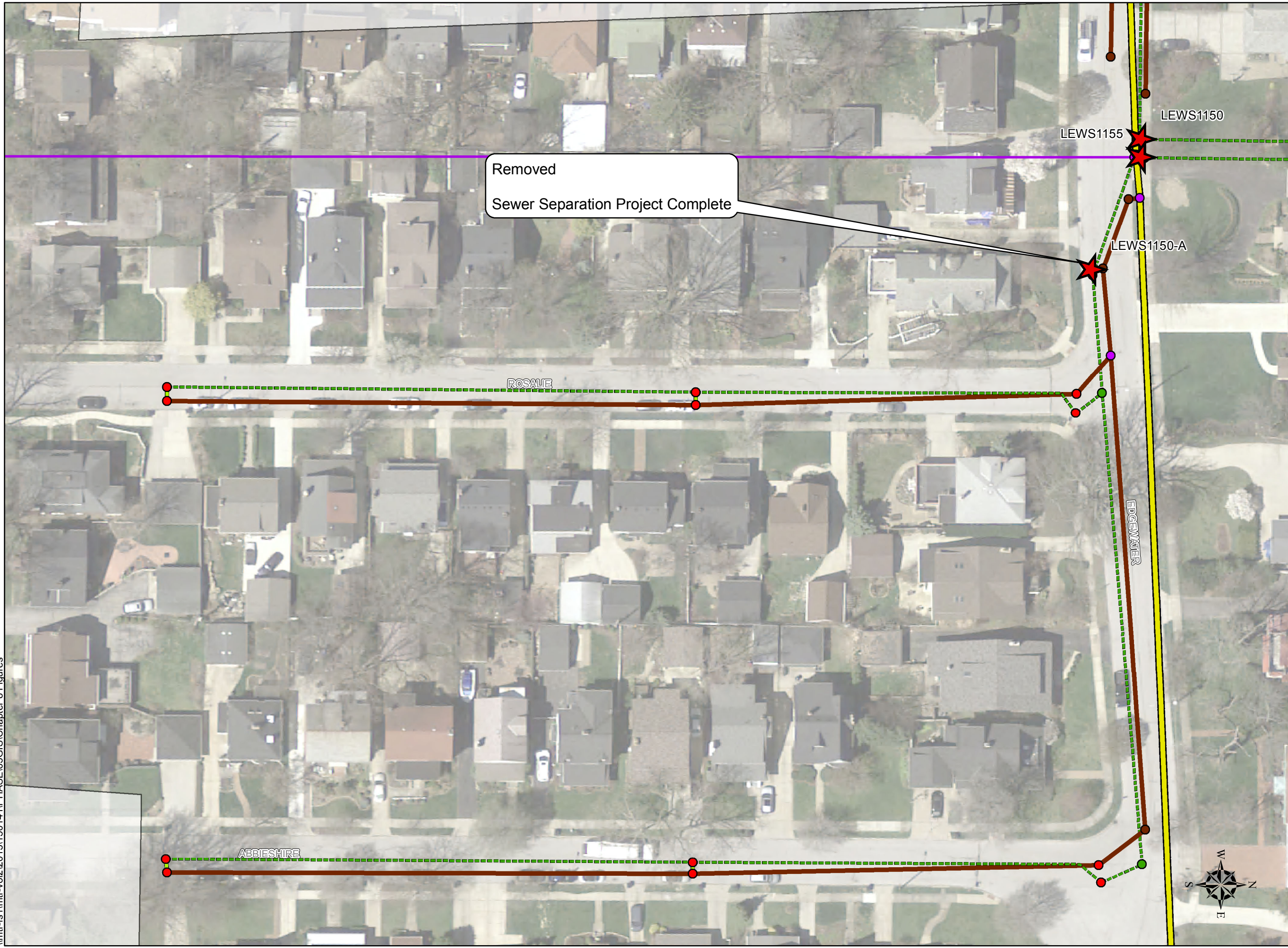
- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



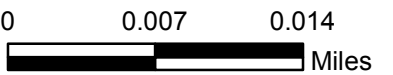
LEWS1150
Figure 8-10

\\mtr-fs1\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures

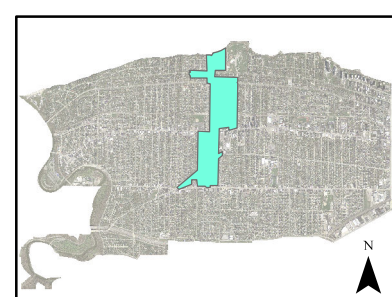
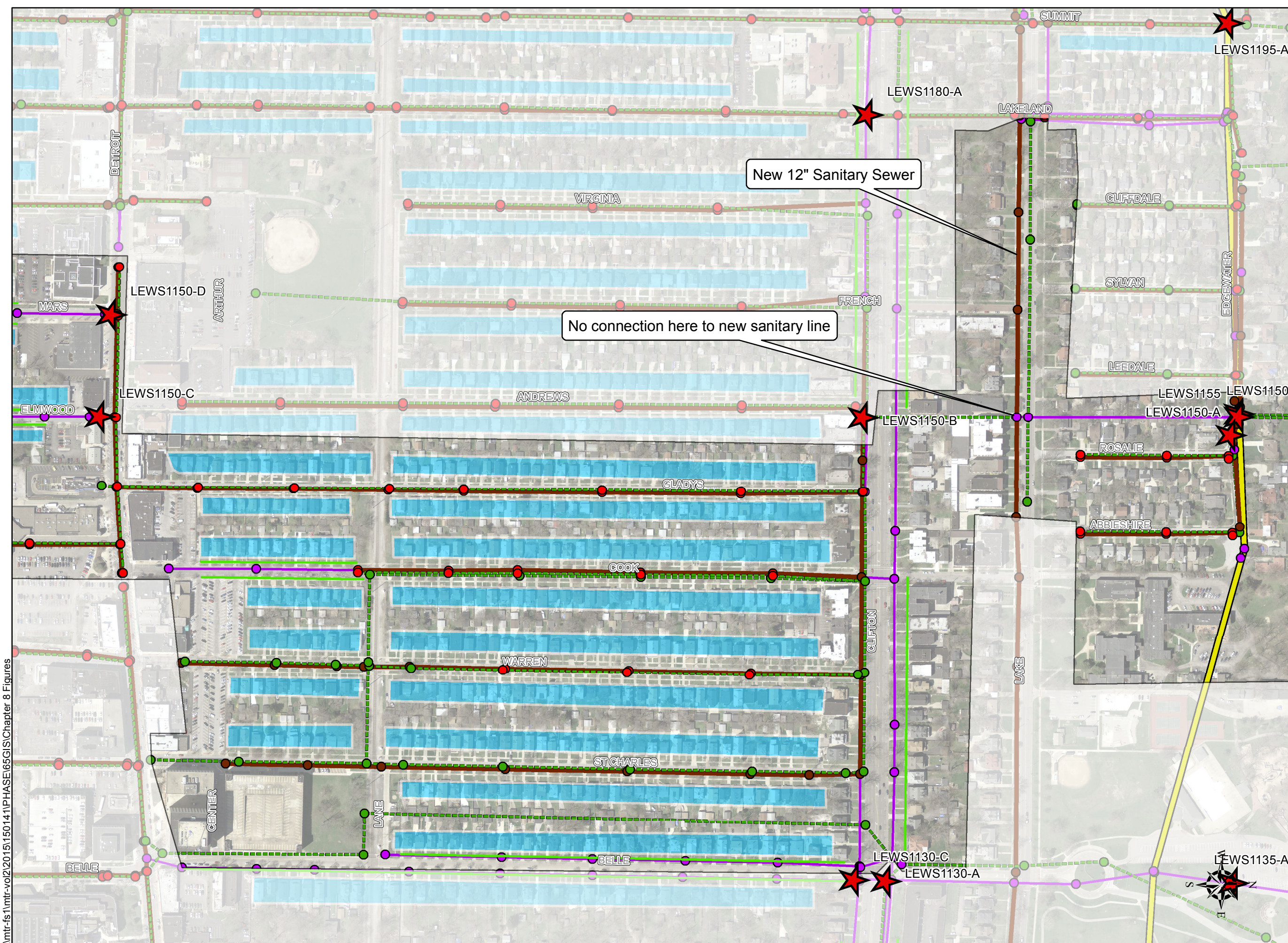


- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

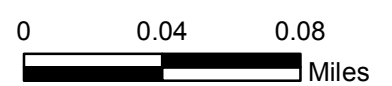


LEWS1150
Figure 8-10a

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures

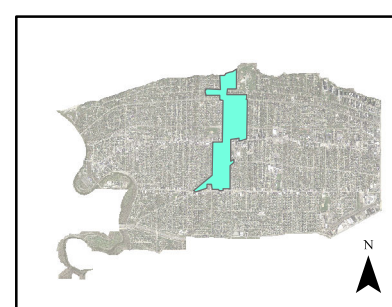
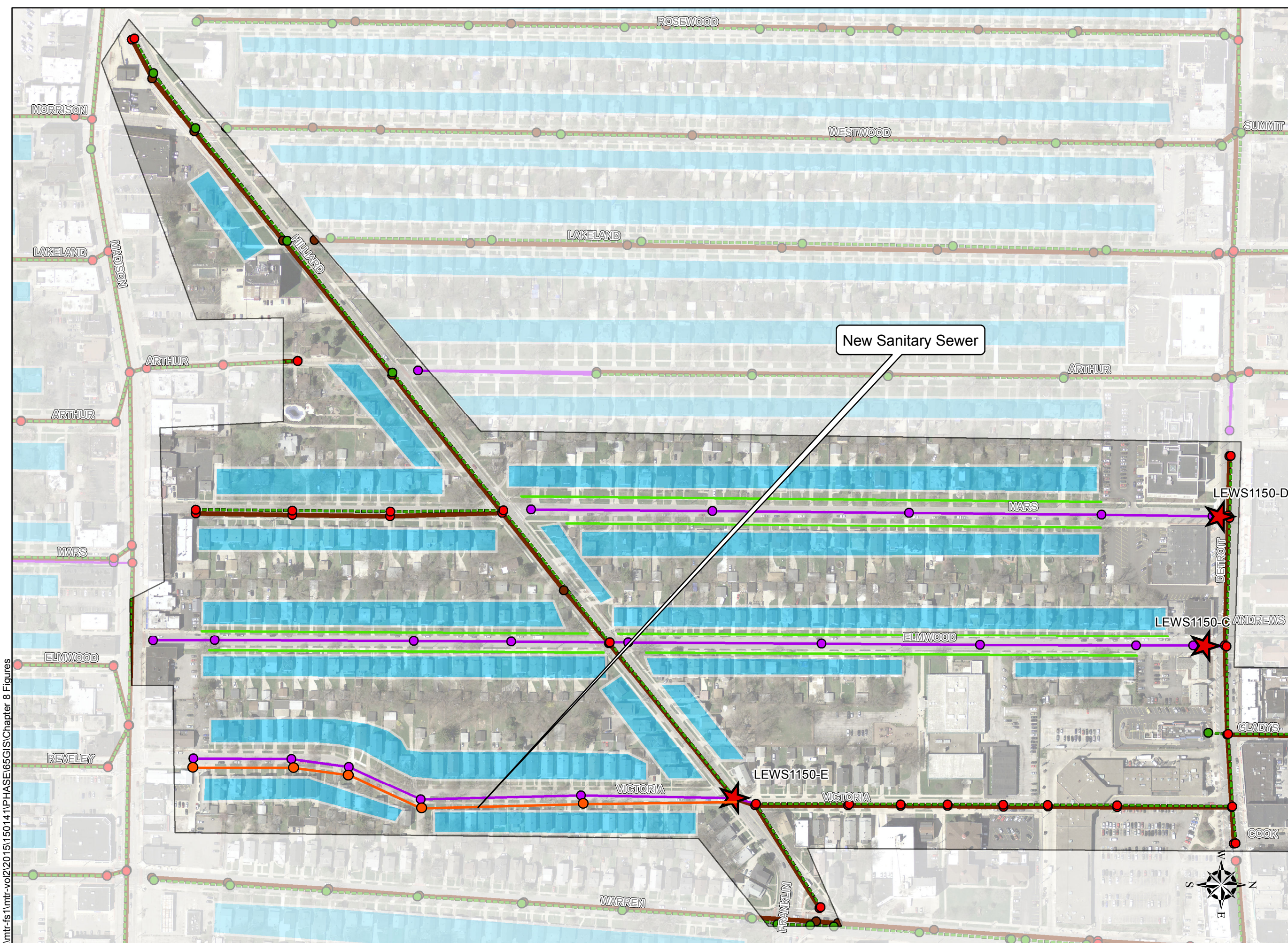


- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORSD
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORSD
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



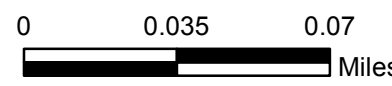
LEWS1150
Figure 8-10b

\\mtr-fs\mnt-rvol20151015101411\PHASE\65GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



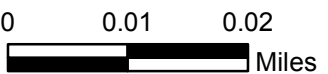
LEWS1150
Figure 8-10c

\\mtr-fs1\mtr-vo\2015\150141\PHASE\65\GIS\Chapter 8 Figures



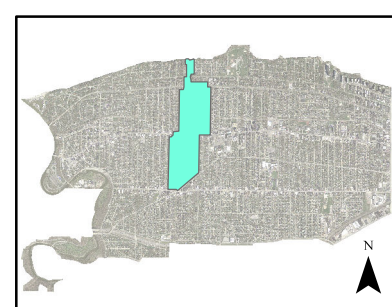
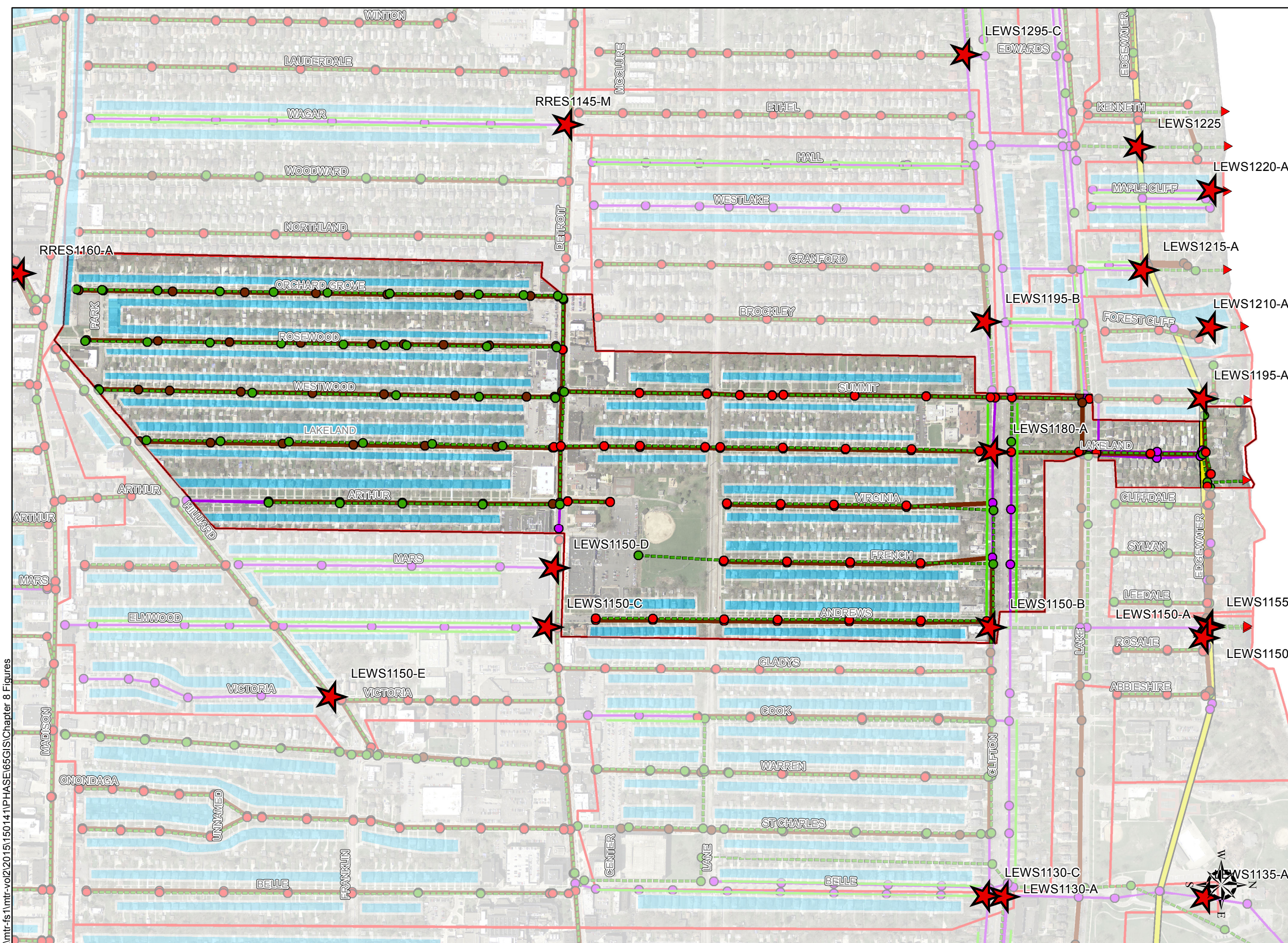
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



LEWS1155
Figure 8-11

\\mtr-fs\1\mtr-vol2\2015\150141\PHASE\65GIS\Chapter 8 Figures



Legend

Source Control

Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

Overflow site

Outfalls

Sewer Type

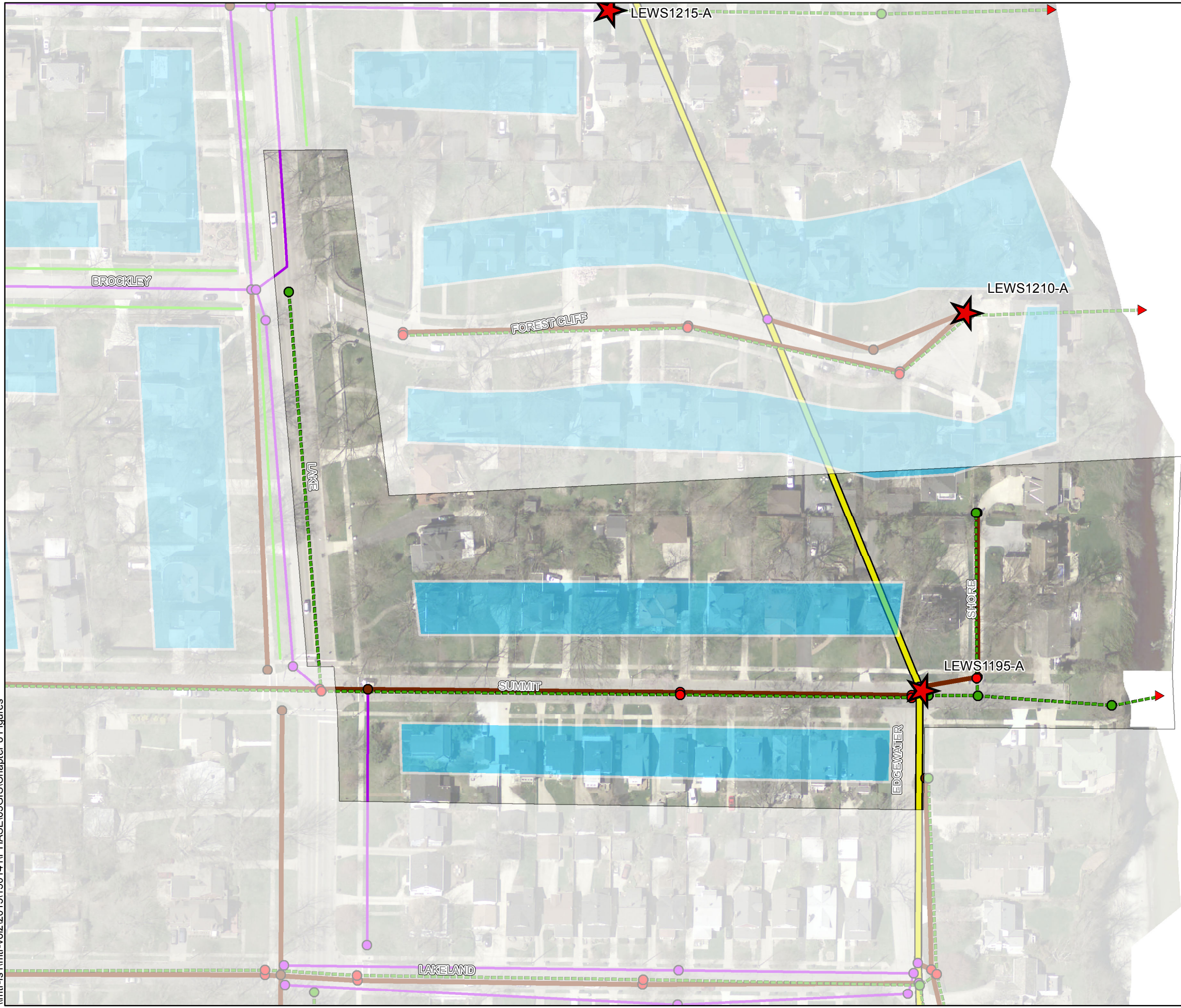
- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.075 0.15 Miles



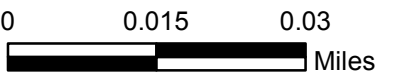
LEWS1180
Figure 8-12

\\mtr-fs1\mtr-vol2\2015\15014\1\PHASE\65\GIS\Chapter 8 Figures

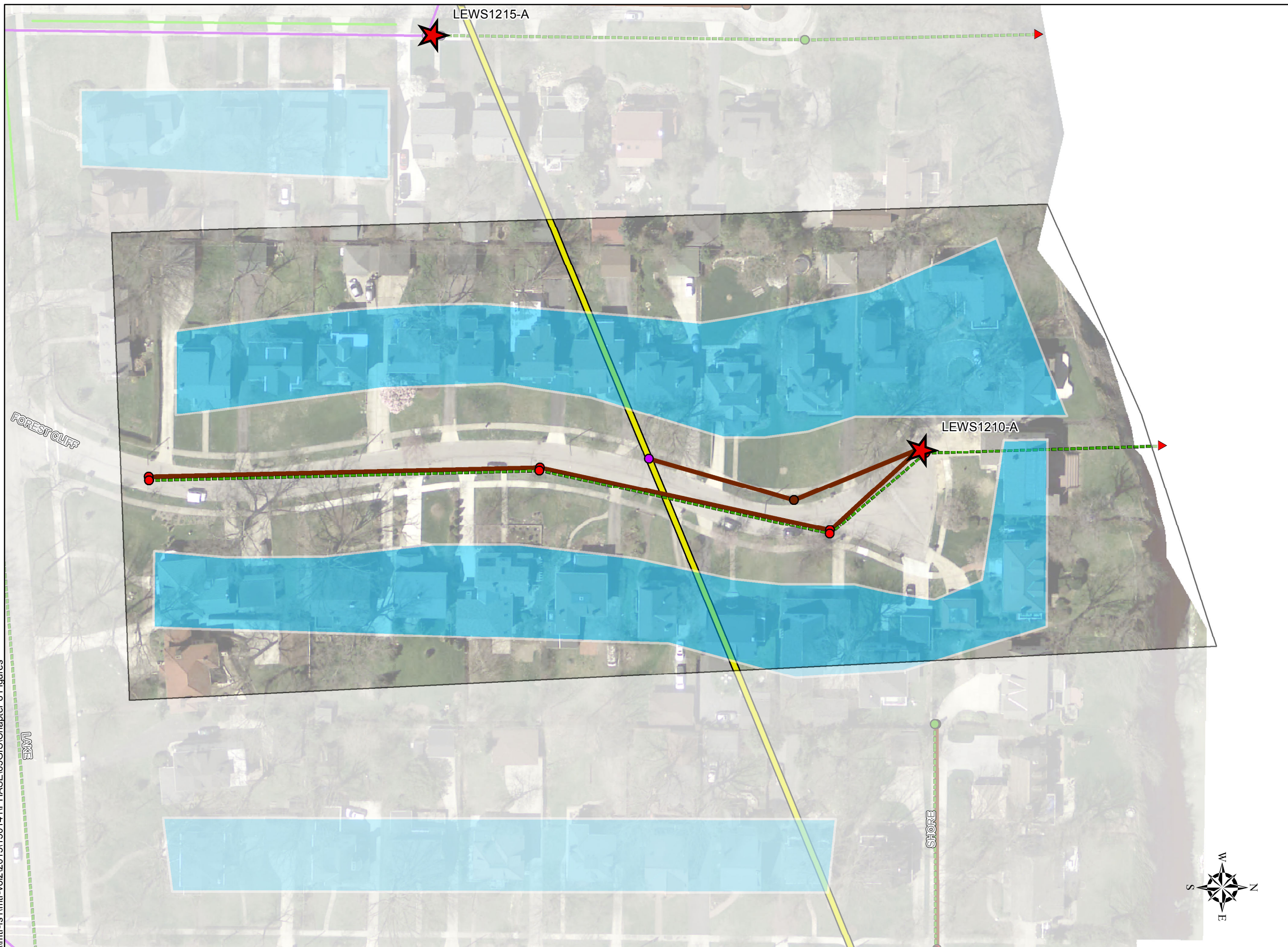


Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORSD
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORSD
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



LEWS1195
Figure 8-13



Legend

-  Source Control
 Green Infrastructure

Manhole Type

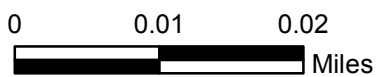
- Combined
- Sanitary
- Storm
- Over/Under
- NEORSD



-  Outfalls

Sewer Type

-  Combined
-  INT
-  NEORS D
-  Sanitary
-  Storm
-  WWTP
-  Orifices
-  Pumps
-  Weirs

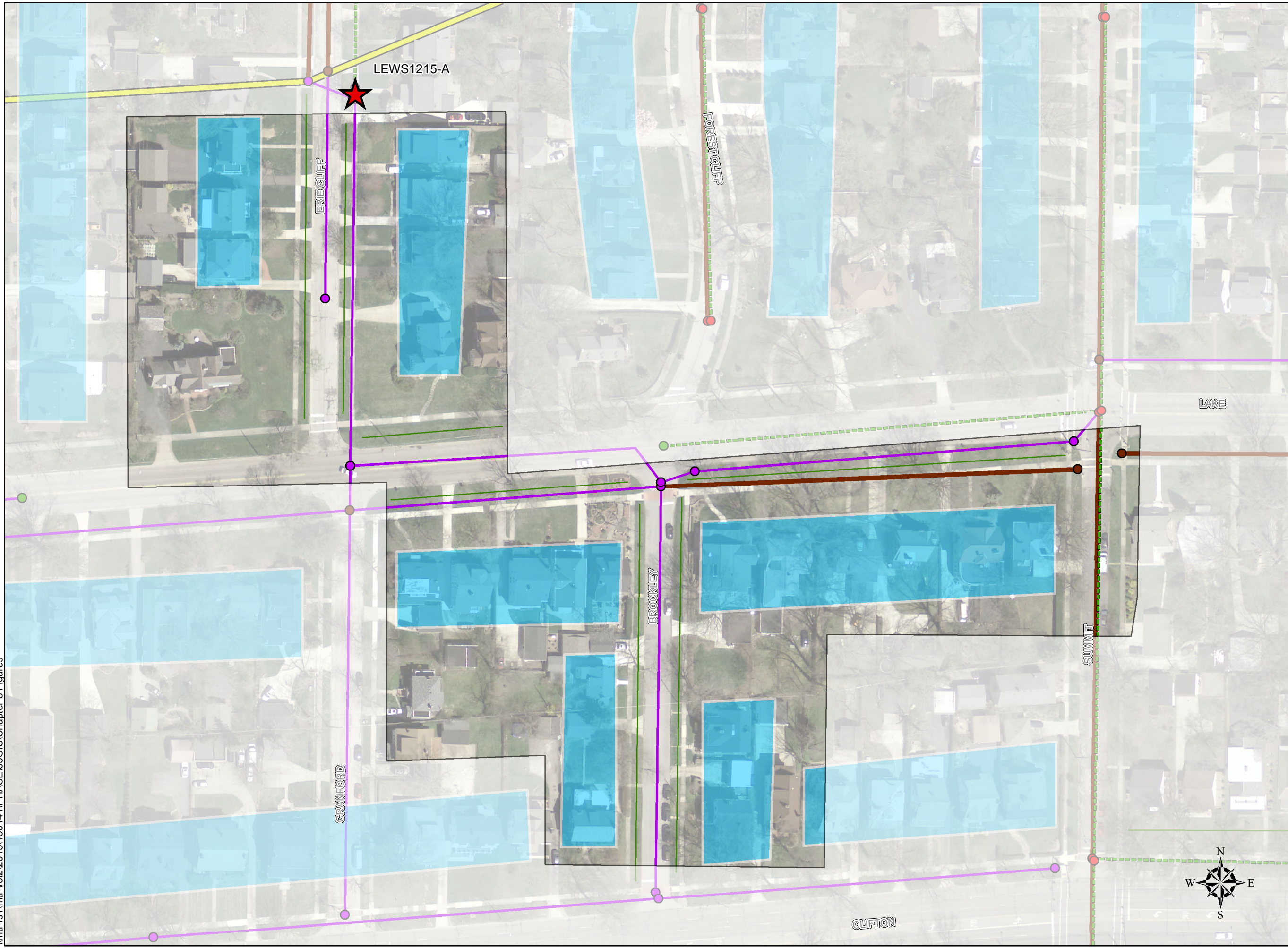


CLEAN WATER
LAKEWOOD



LEWS1210
Figure 8-14

\\mtr-fs\mtr-vol2015\150141\PHASE\65GIS\Chapter 8 Figures



Legend

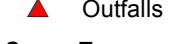
- Source Control
- Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS



Overflow site



Outfalls

Sewer Type

- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.01 0.02 Miles

CLEAN WATER
LAKEWOOD

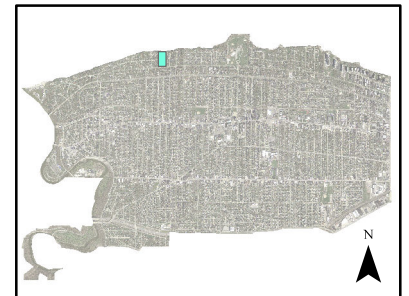
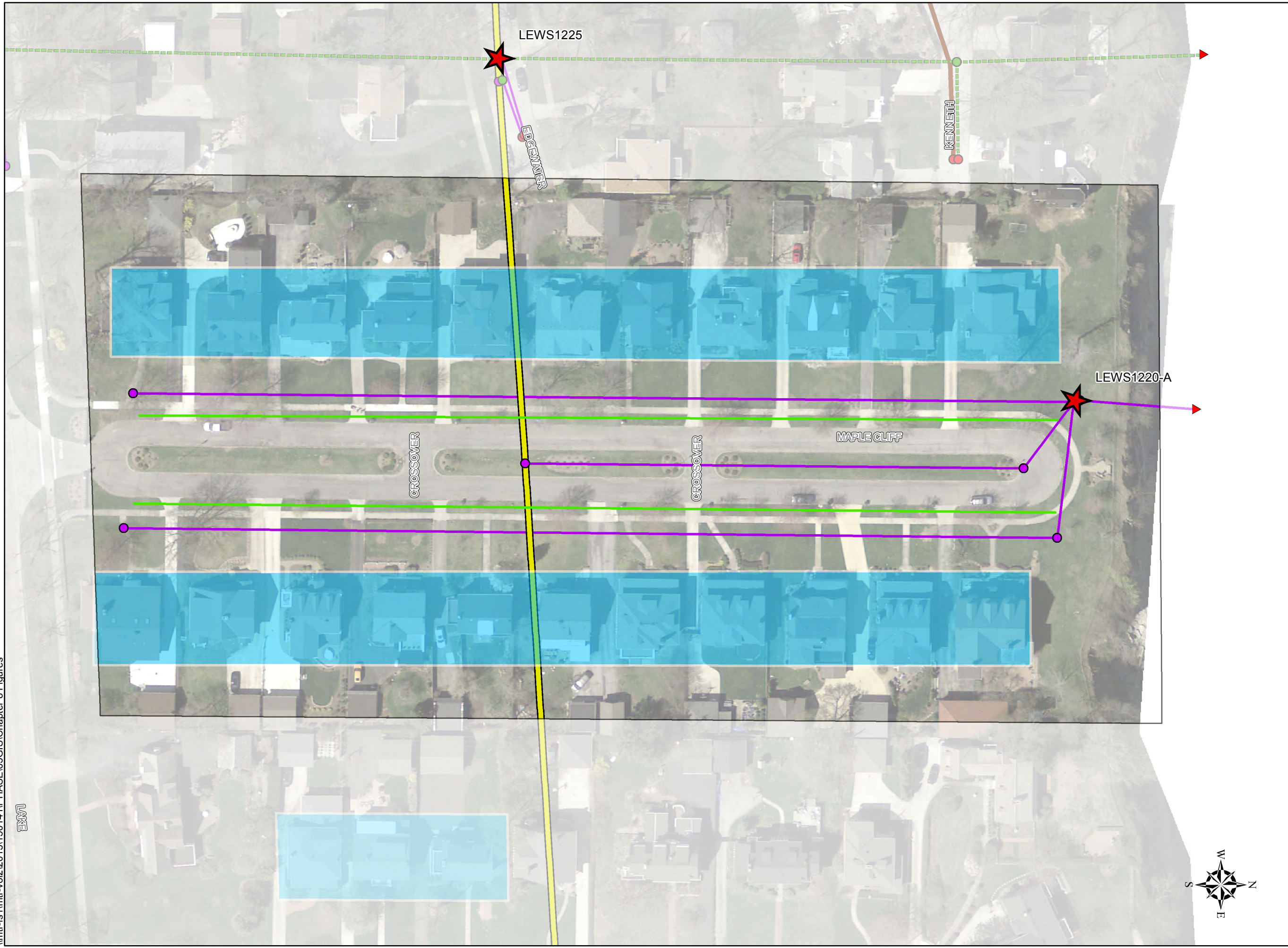


Rebuilding the Pipeline for Our Future



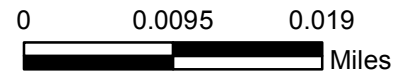
LEWS1215
Figure 8-15

\\mtr-fs1\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures

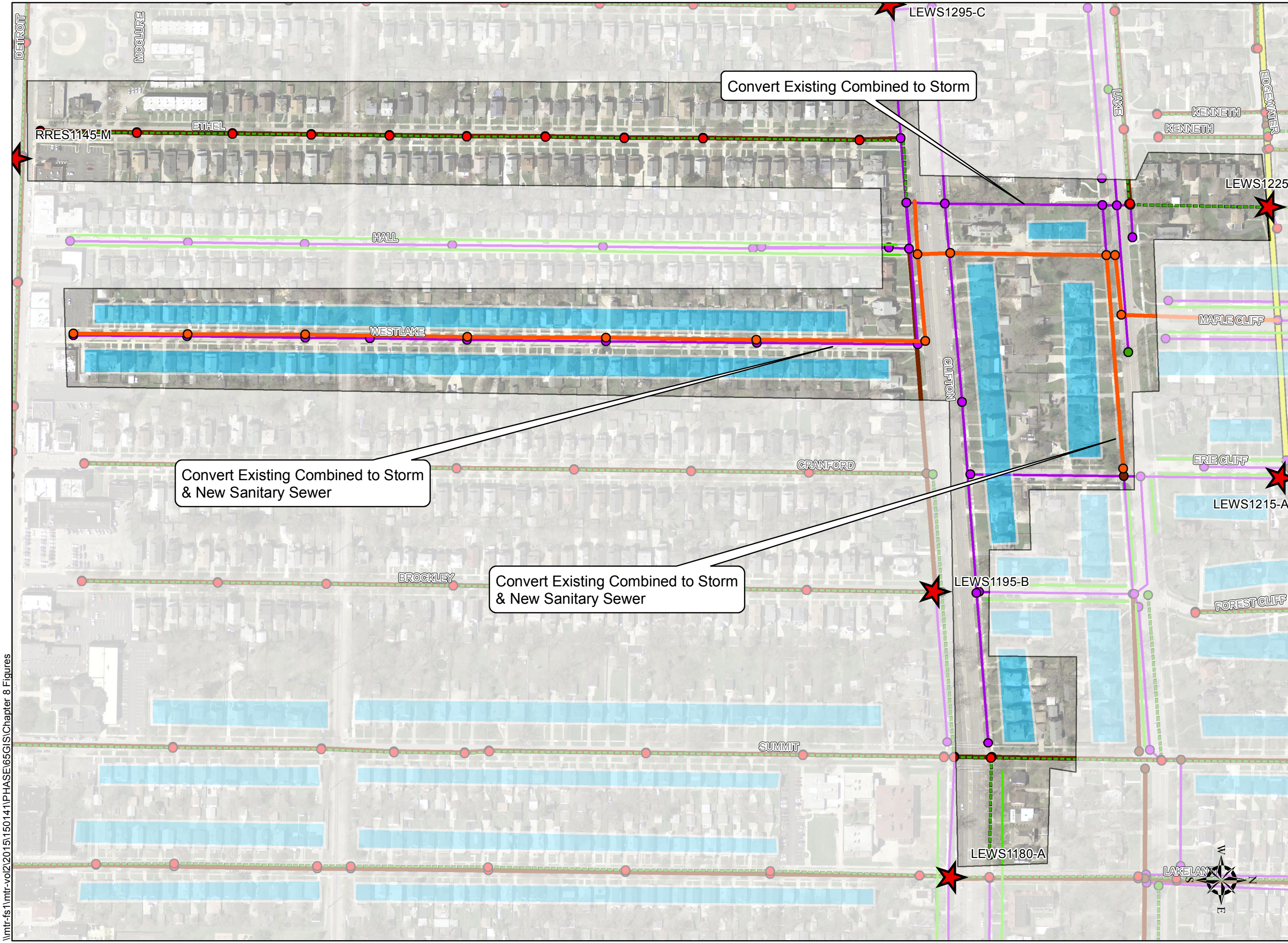


Legend

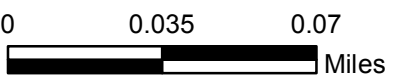
- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



LEWS1220
Figure 8-16

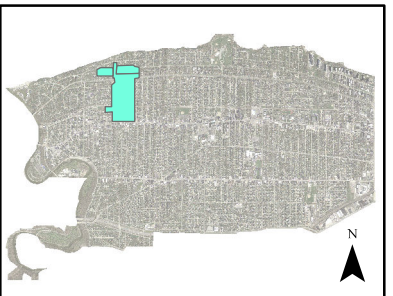
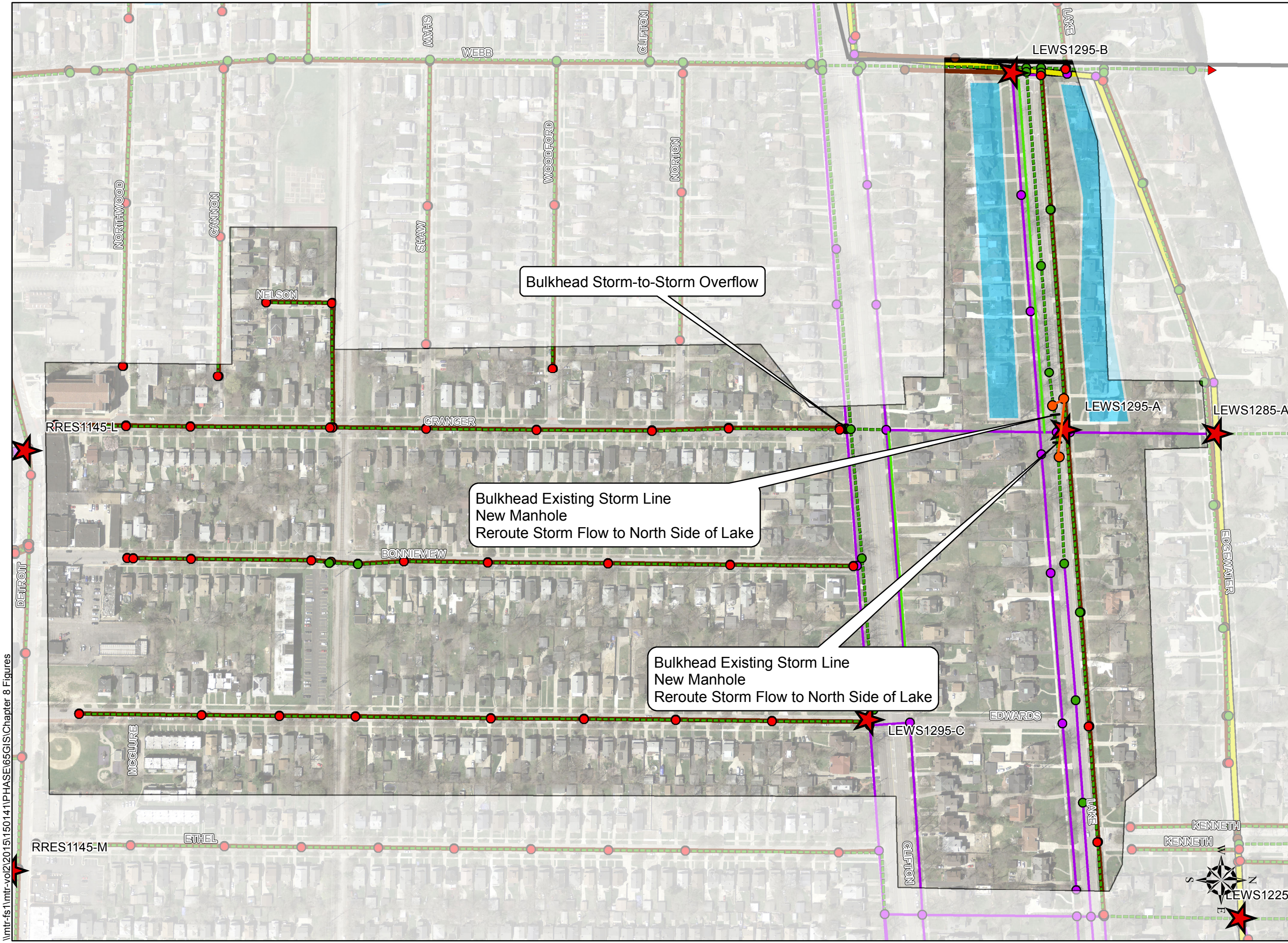


- Legend**
- Source Control
 - Green Infrastructure
- Manhole Type**
- Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
- Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



LEWS1225
Figure 8-17

\\mtr-fs\mtr-vol2015150141\PHASE\GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

Overflow site

Outfalls

Sewer Type

- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

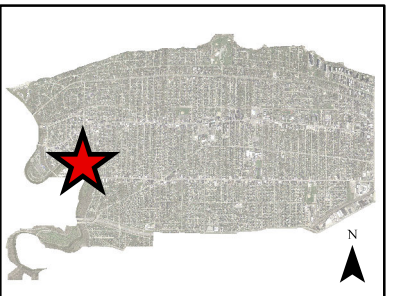
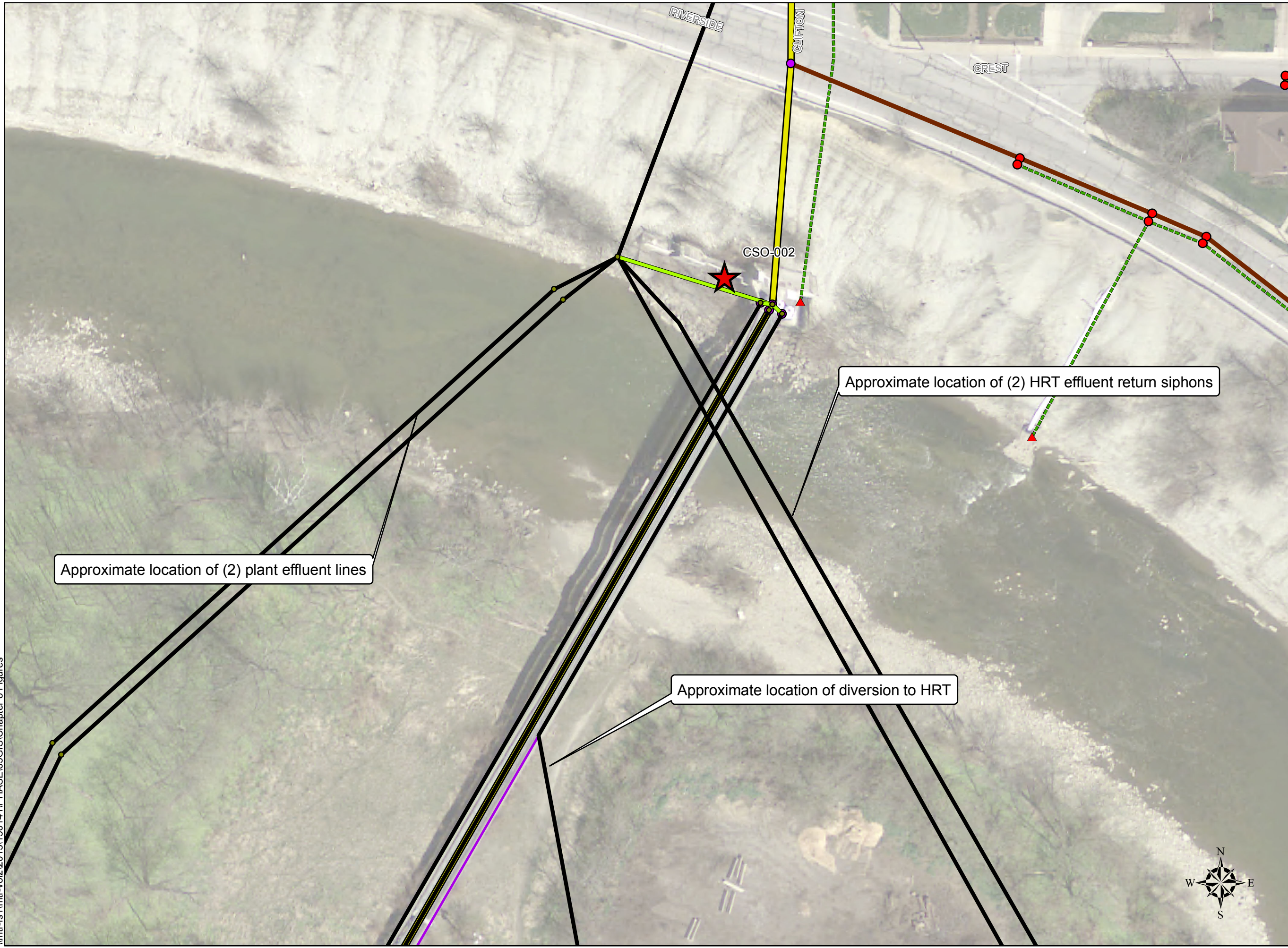
0 0.035 0.07 Miles



LEWS1285/95
Figure 8-18

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures

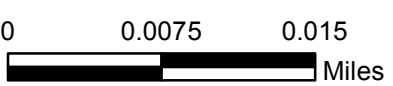
\\mtr-fs\mtr-vol2\2015\15014\1\PHASE\65GIS\Chapter 8 Figures



Legend

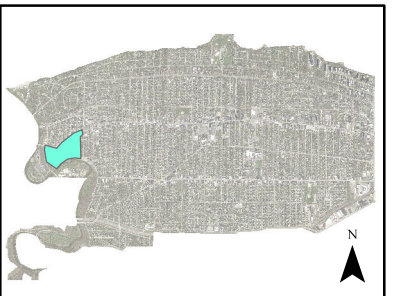
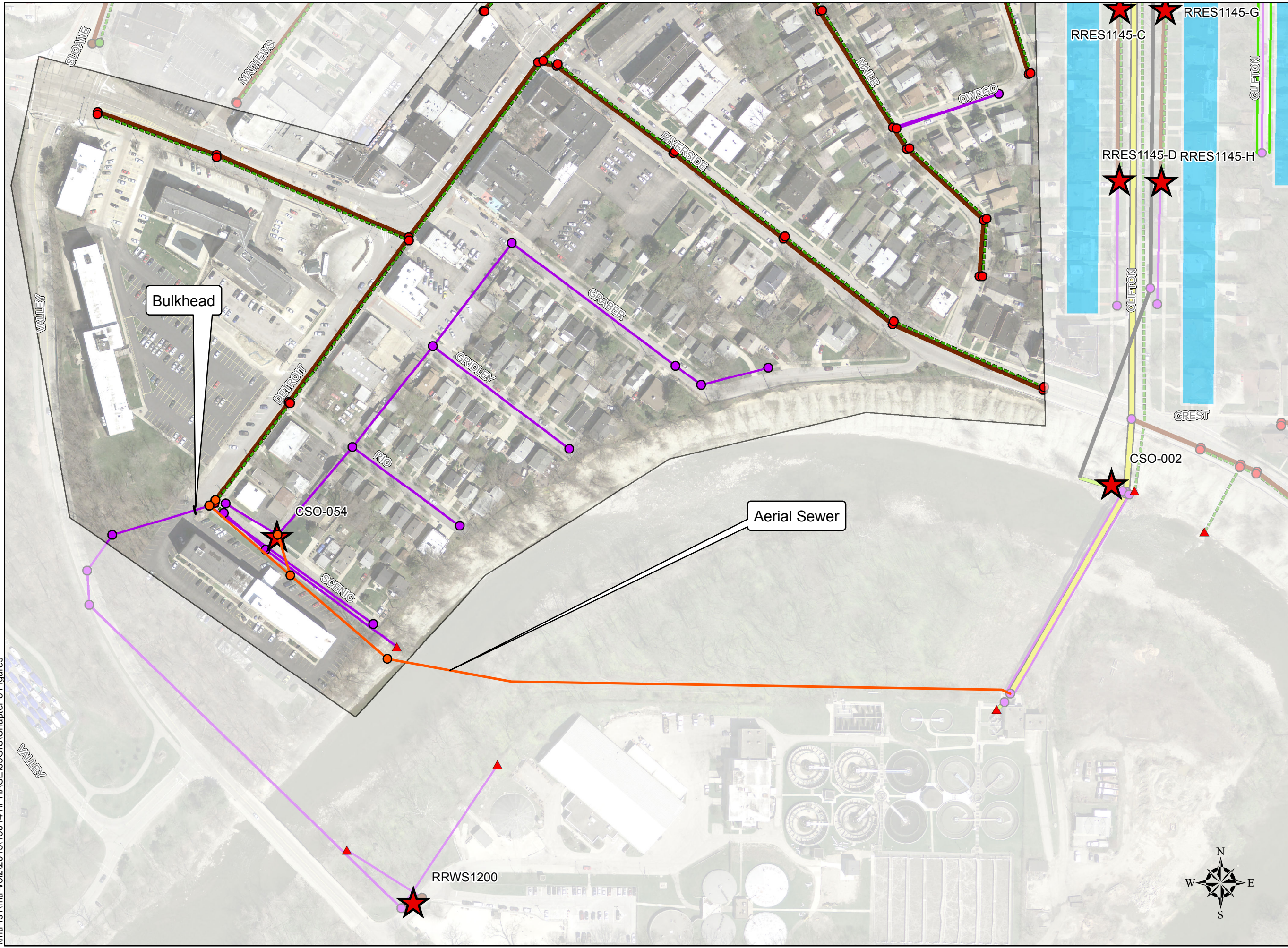
- Manhole Type**
- Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site

- Sewer Type**
- Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



WWTP Outfall
Figure 8-19

\\mtr-fs\mtr-vol2\2015\150141\PHASE\65GIS\Chapter 8 Figures



Legend

Source Control

Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

Overflow site

Outfalls

Sewer Type

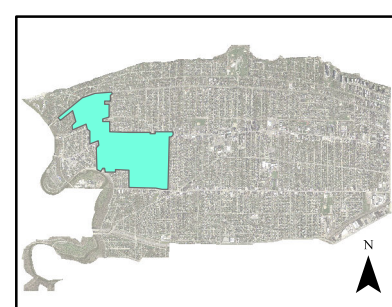
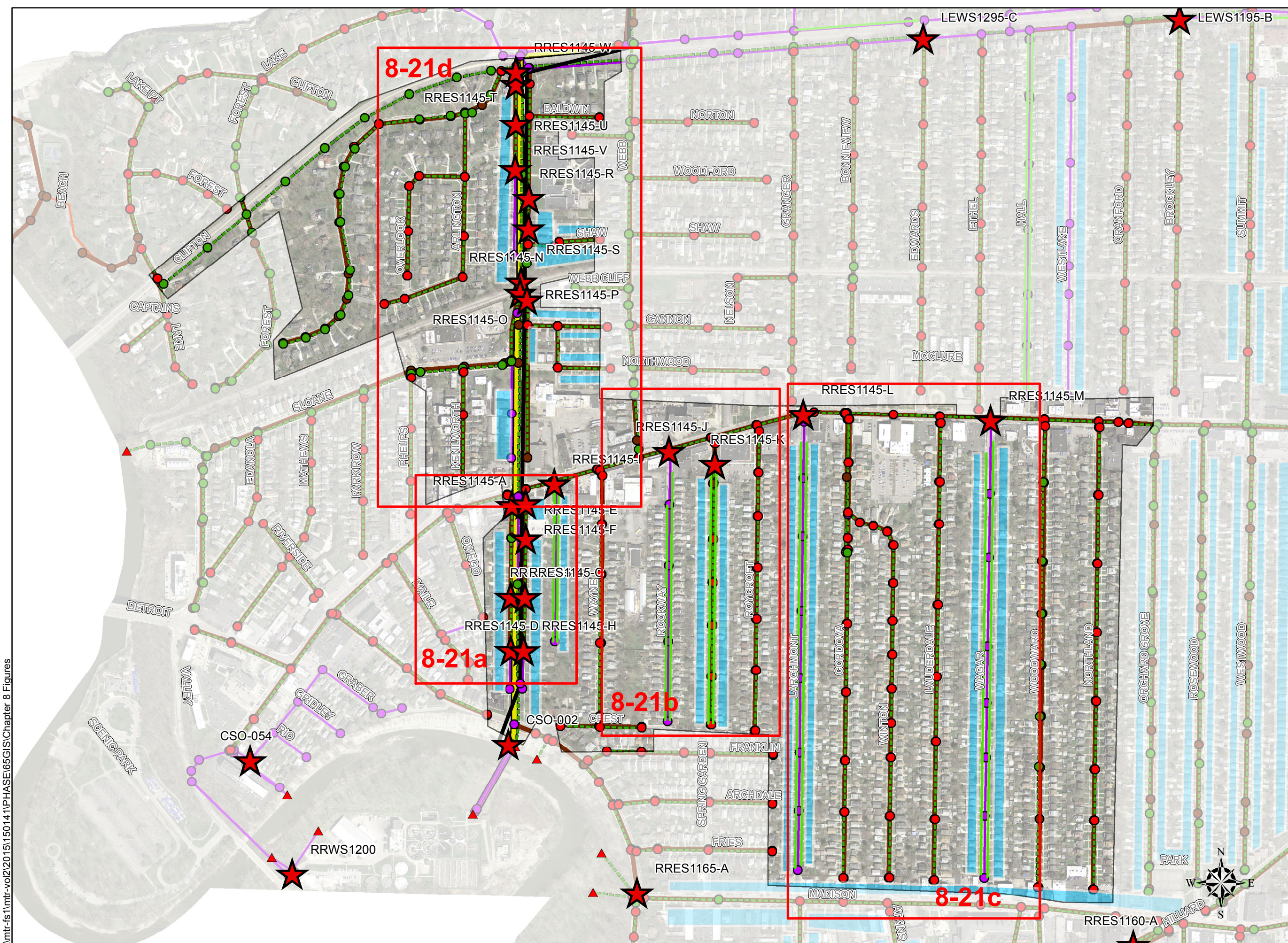
- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.025 0.05 Miles



RRES1140
Figure 8-20

\\mtr-fs\1\mtr-vol2015\150141\PHASE\65GIS\Chapter 8 Figures



Legend

Source Control

Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

Overflow site

Outfalls

Sewer Type

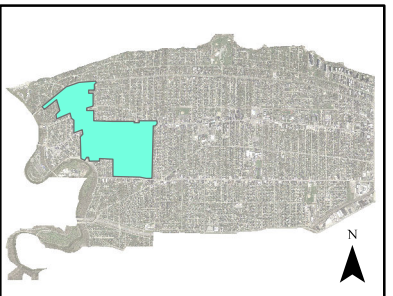
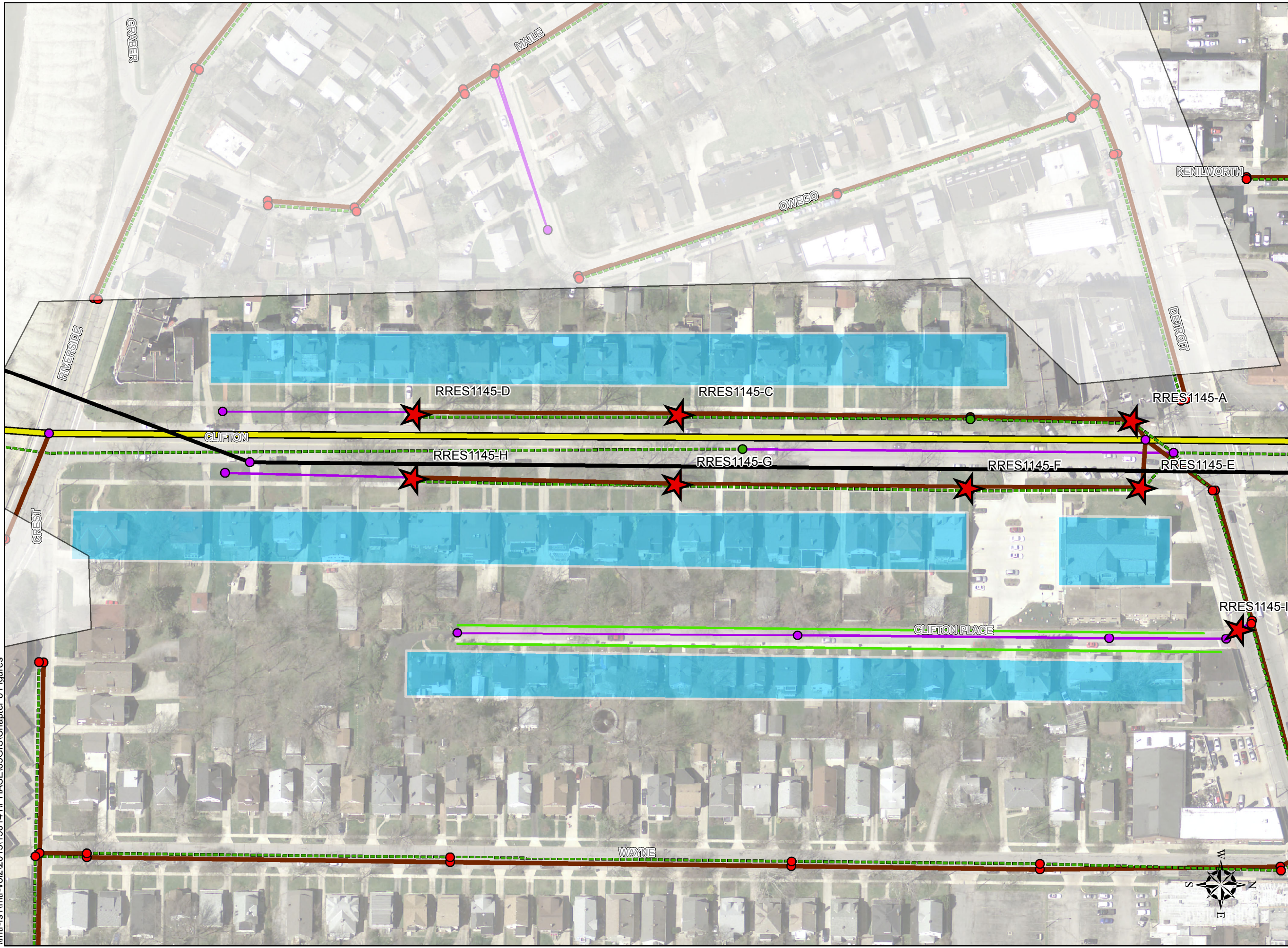
- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.08 0.16 Miles



RRES1145
Figure 8-21

\\mtr-fs\mtr-vol2015\150141\PHASE\65GIS\Chapter 8 Figures



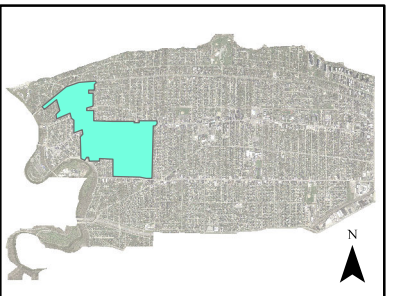
Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

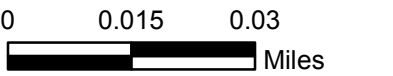
0 0.015 0.03 Miles



RRES1145
Figure 8-21a



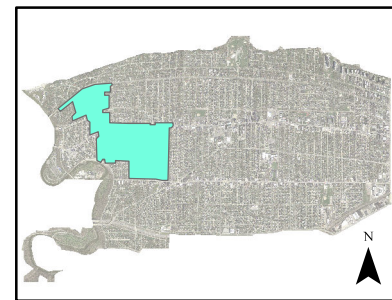
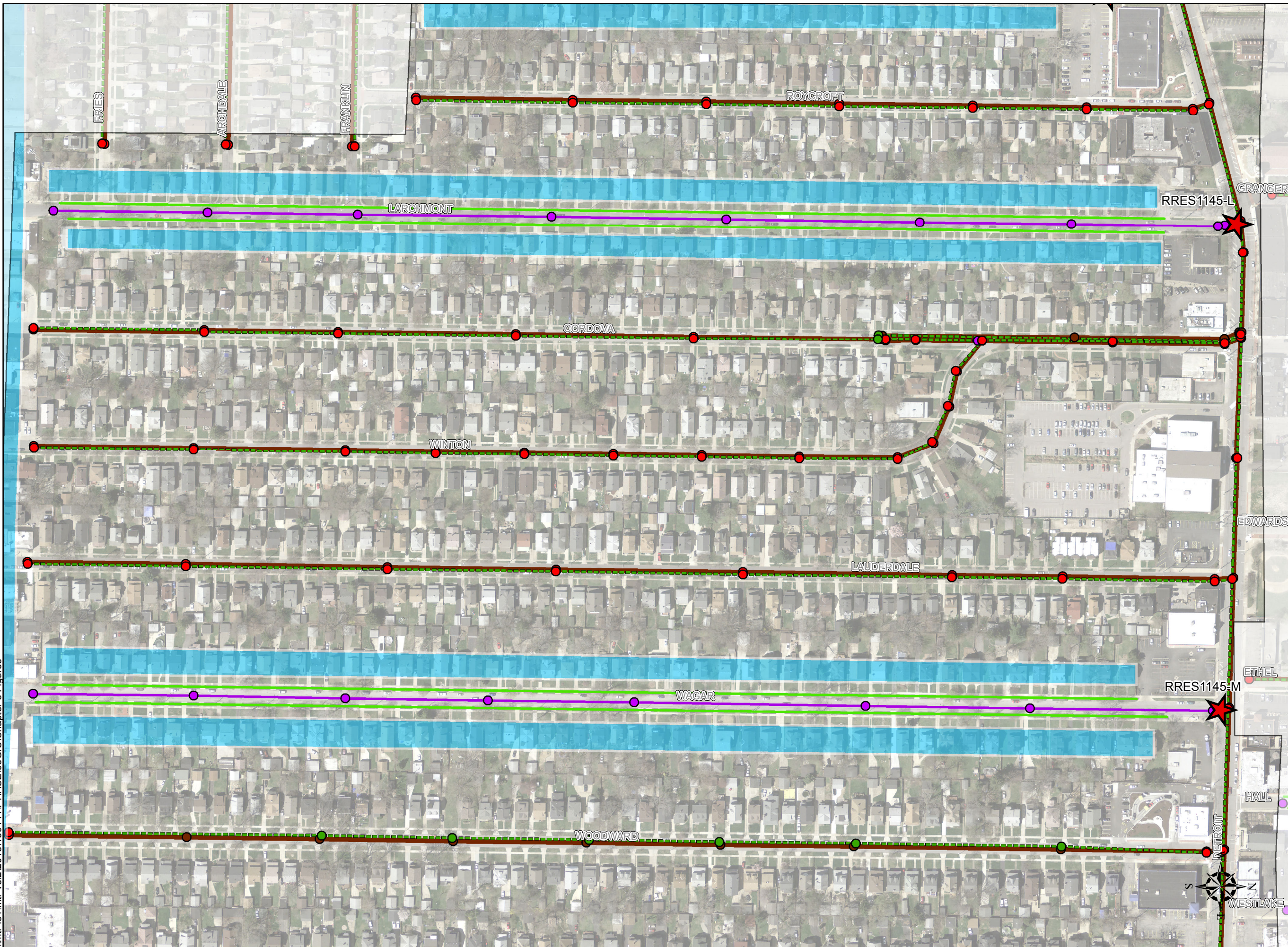
- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs



RRES1145
Figure 8-21b

\\mtr-fs\mnt-rvol2015101510141\PHASE\65GIS\Chapter 8 Figures

\\mtr-fs\mnt-rvol2015150141\PHASE\656GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORS

- Overflow site

Outfalls

- Outfalls

Sewer Type

- Combined
- INT
- NEORS
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.03 0.06 Miles

CLEAN WATER
LAKEWOOD

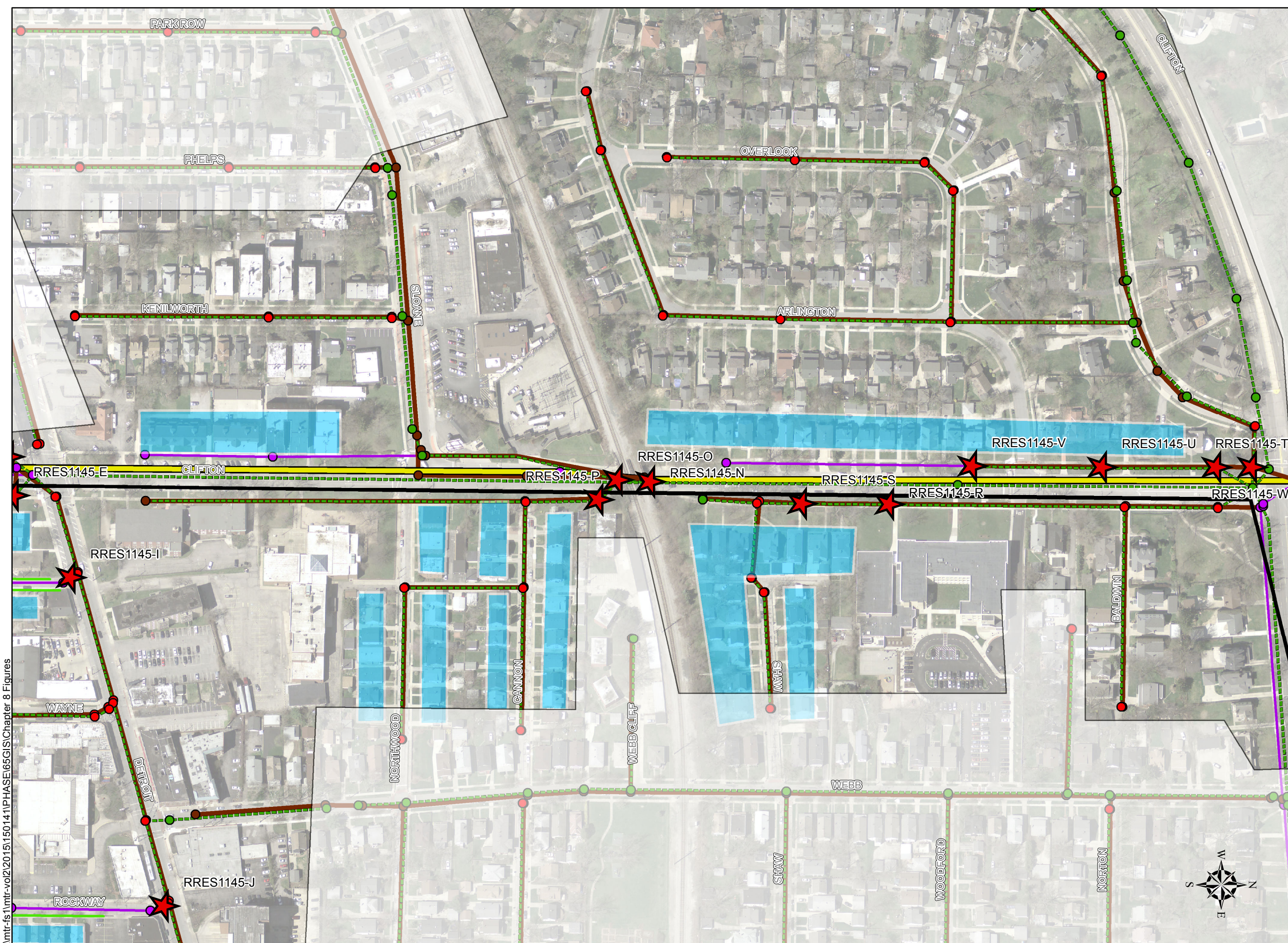


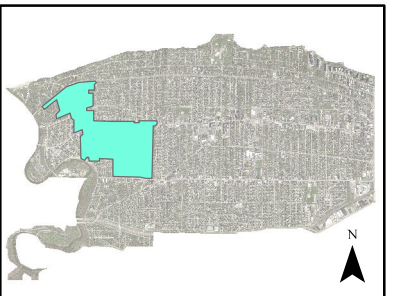
Rebuilding the Pipeline for Our Future

CT Consultants
engineers | architects | planners

RRES1145
Figure 8-21c

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures





Legend

- Source Control
- Green Infrastructure
- Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
- Overflow site
- Outfalls
- Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

0 0.025 0.05 Miles

CLEAN WATER LAKEWOOD

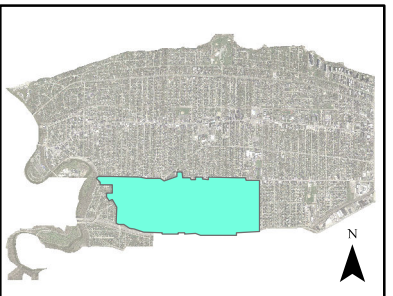
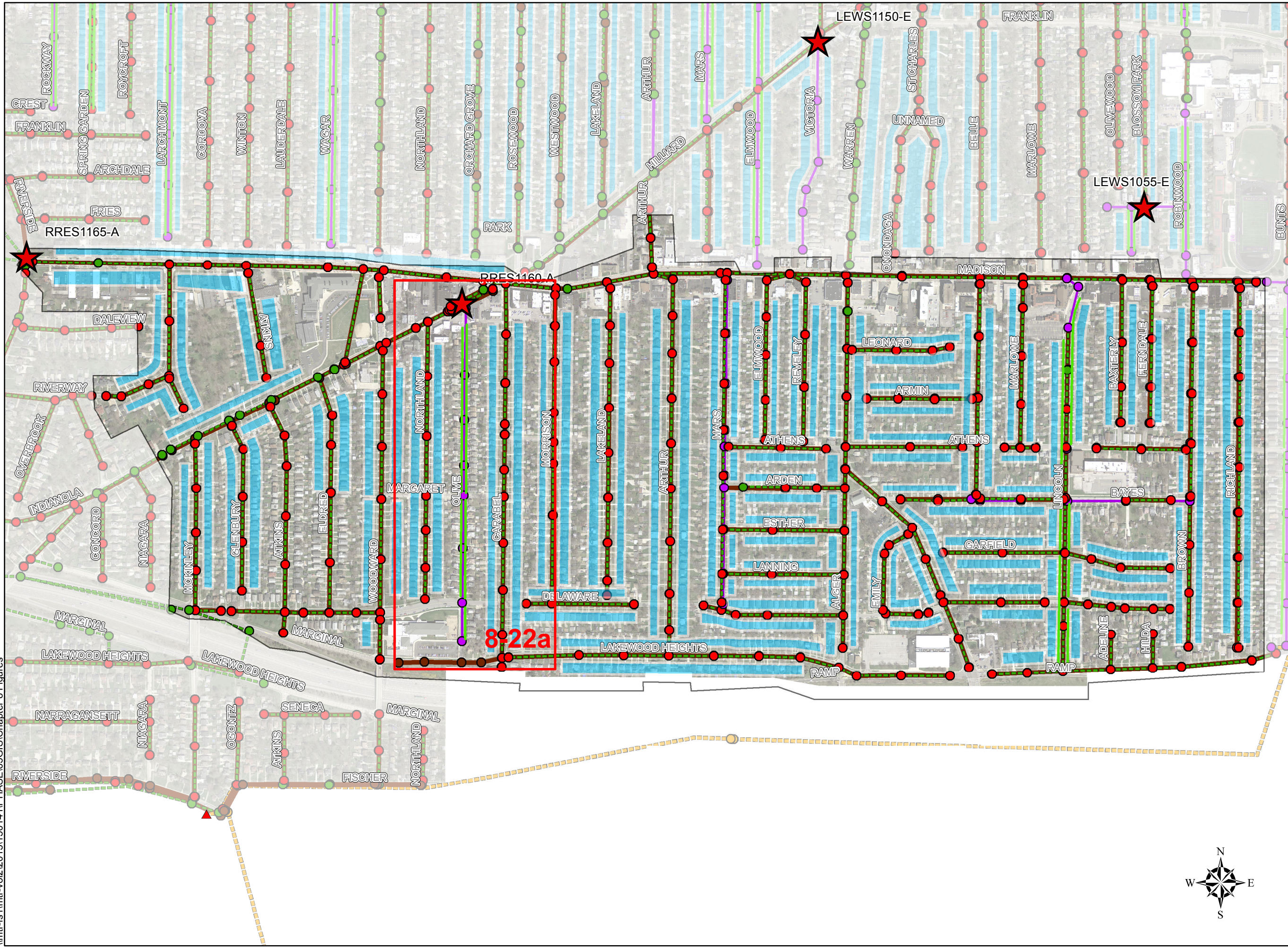


Rebuilding the Pipeline for Our Future

CT Consultants
engineers | architects | planners

RRES1145
Figure 8-21d

\\mtr-fs\mnt-rvol2\2015\150141\PHASE\65GIS\Chapter 8 Figures



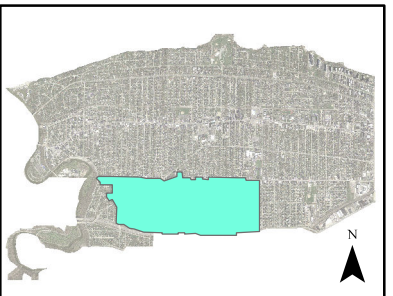
- Legend**
- Source Control
 - Green Infrastructure
 - Manhole Type**
 - Combined
 - Sanitary
 - Storm
 - Over/Under
 - NEORS
 - Overflow site
 - Outfalls
 - Sewer Type**
 - Combined
 - INT
 - NEORS
 - Sanitary
 - Storm
 - WWTP
 - Orifices
 - Pumps
 - Weirs

0 0.09 0.18 Miles



RRES1165
Figure 8-22

\\mtr-fs\mtr-vol2015150141\PHASE\65GIS\Chapter 8 Figures



Legend

- Source Control
- Green Infrastructure

Manhole Type

- Combined
- Sanitary
- Storm
- Over/Under
- NEORSD

★ Overflow site

▲ Outfalls

Sewer Type

- Combined
- INT
- NEORSD
- Sanitary
- Storm
- WWTP
- Orifices
- Pumps
- Weirs

0 0.03 0.06 Miles



RRES1160
Figure 8-22a

**Table 8-2: IWWIP Modeling Results after Incorporating Control Technologies**

Overflow Reference	Location	# of overflows implementing IWWIP*	Total Volume (MGal) implementing IWWIP	IWWIP Technology	Figure Reference
LEWS1035 (CSO-059)	Edgewater east of Nicholson	0	-	DIV or DB	8-2A
LEWS1035-A	Thoreau & Clifton	Storm Only	-	SC, SS	8-2B
LEWS1040-A	North end of Nicholson	-2	-	SC/PS	8-3A
LEWS1040-B	Clarence @ Detroit	1	0.066	GI, SC	8-3B
LEWS1040-C	Grace & Detroit	0	-	GI, SC	8-3C
LEWS1040-D	Detroit Rd. east of Elbur	3	0.039	GI, SC	8-3D
LEWS1040-E	Detroit & Elbur	0	-	GI, SC	8-3E
LEWS1040-F	Wyandotte @ Detroit	0	-	GI, SC	8-3F
LEWS1040-G	Madison Ave. at Lewis	4	0.705	GI, REL	8-3G
LEWS1040-H	Madison at Elbur	1	0.005	GI, REL	8-3H
LEWS1045-A	North end of Wilbert	0	-	SC, PS	8-4
LEWS1055-A	Edgewater BTW. Homewood & Wilbert	Storm Only	-	DIV	8-5A
LEWS1055-C	Detroit Ave. @ Parkwood Ave.	1	0.008	GI, SC	8-5B
LEWS1055-D	Robinwood Ave. @ Detroit Ave.	1	0.002	GI, SC	8-5C
LEWS1055-E	Cedarwood & Blossom	0	-	GI, SC	8-5D
LEWS1070-A	Homewood Ave. (terminal san. MH)	0	-	PS	8-6A
LEWS1070-B	NE of Clifton Blvd. & Whippoorwill Ave.	2	0.041	GI	8-6B
LEWS1110 (CSO-058)	Edgewater BTW. Roy & Kirtland	0	-	GI, SC, and SS	8-7
LEWS1130-A	North side Clifton Blvd. @ Marlowe Ave.	Overflow Removed	-	N/A	8-8A



Overflow Reference	Location	# of overflows implementing IWWIP*	Total Volume (MGal) implementing IWWIP	IWWIP Technology	Figure Reference
LEWS1130-B	NE corner Belle Ave. & Clifton Blvd	Overflow Removed		N/A	8-8B
LEWS1130-C	SE corner Belle Ave. & Clifton Blvd.	0	-	GI, SC	8-8B
LEWS1135 (CSO-057)	Lakewood Park	4	0.070	GI, SC	8-9
LEWS1150 (CSO-056B)	Edgewater btw. Leedale & Rosalie	Reported at other locations	-	RD, SS	8-10A
LEWS1150-A	Edgewater at Rosalie	Storm Only	-	SS	8-10B
LEWS1150-B	Andrews Avenue at Clifton Blvd.	Overflow Removed	-	GI, SC	8-10C
LEWS1150-C	Detroit @ Elmwood	1	0.044	GI, SC	8-10D
LEWS1150-D	Detroit @ Mars	1	0.009	GI, SC	8-10E
LEWS1150-E	Victoria @ Hilliard	Overflow Removed	-	SS, SC	8-10F
LEWS1155 (CSO-056A)	Edgewater btw. Leedale & Rosalie	Storm Flow Only	-	BLK	8-11
LEWS1180-A	Clifton & Lakeland	0	-	GI, SC	8-12
LEWS1195-A	Summit Ave. @ Edgewater Ave.	0	-	HRT, DIV, GI, SC	8-13
LEWS1210-A	Forest Cliff Dr.	-5	-	BLK, SC	8-14
LEWS1215-A	Erie Cliff	0	-	GI, SC	8-15
LEWS1220-A	NW of north end of Maple Cliff Dr.	0	-	GI, SC	8-16



Overflow Reference	Location	# of overflows implementing IWWIP*	Total Volume (MGal) implementing IWWIP	IWWIP Technology	Figure Reference
LEWS1225 (CSO-055)	Edgewater BTW. Kenneth & Maple Cliff	Storm Flow only	-	SS, SC	8-17
LEWS1285-A	Edgewater btw Webb & Kenneth	0	-	N/A	8-18A
LEWS1295-A	Lake Ave. btw Kenneth & Webb	0	-	GI, RD	8-18B
LEWS1295-B	Webb and Lake	0	-	GI, SC	8-19
LEWS1295-C	Edwards Ave. @ Clifton Blvd.	0	-	GI, SC	8-18C
WWTP OUTFALL (CSO-002)	Webb Road	0	-	HRT	8-20
RRES1140 (CSO-054)	Scenic St.@ Graber Alley	0	-	BLK	8-21
RRES1145-A	SW corner of W. Clifton and Detroit	0		SC	8-22A
RRES1145-C	1460 West Clifton	0	-	SC	8-22A
RRES1145-D	1488 West Clifton	0	-	SC	8-22A
RRES1145-E	SE corner of W. Clifton and Detroit	0	-	SC	8-22A
RRES1145-F	1429 West Clifton	-4	-	SC	8-22A
RRES1145-G	1459 West Clifton	0	-	SC	8-22A
RRES1145-H	1491 West Clifton	0	-	SC	8-22A
RRES1145-I	Clifton Place @ Detroit Ave.	0	-	SC, GI	8-23A



Overflow Reference	Location	# of overflows implementing IWWIP*	Total Volume (MGal) implementing IWWIP	IWWIP Technology	Figure Reference
RRES1145-J	Detroit at Rockway	0	-	SC, GI	8-23B
RRES1145-K	1421 Spring Garden Ave.	5	0.231	SC, GI	8-23C
RRES1145-L	Larchmont Ave. @ Detroit Ave.	2	0.173	SC, GI	8-23D
RRES1145-M	Wagar Ave. @ Detroit Ave.	1	0.122	SC, GI	8-23E
RRES1145-N	West Clifton south of RR underpass in center of pavement	0	-	SC	8-23F
RRES1145-O	West Clifton north of RR underpass in center of pavement	Storm Only	-	SC, GI, HRT, DIV or DET	8-23F
RRES1145-P	1285 West Clifton	0	-	SC	8-23F
RRES1145-R	1232 West Clifton	-3	-	SC	8-23G
RRES1145-S	1253-55 West Clifton	0	-	SC	8-23G
RRES1145-T	West Clifton – west side 75 feet south of Clifton	0	-	SC	8-23G
RRES1145-U	1186 West Clifton	0	-	SC	8-23G
RRES1145-V	1214 West Clifton	0	-	SC	8-23G
RRES1145-W	SW corner of West Clifton & Clifton	0	-	SC	8-23G
RRES1160-A	Olive Ave. @ Hilliard Rd.	Storm Only	-	GI	8-24



Overflow Reference	Location	# of overflows implementing IWWIP*	Total Volume (MGal) implementing IWWIP	IWWIP Technology	Figure Reference
RRES1165-S (CSO-052)	Riverside & Madison	0	-	SC, GI	8-25
RRWS1200 (CSO-053)	Valley @ WWTP	Overflow removed	-	RD	8-26
Total			1.515		

* Negative numbers in Table 8-2 indicate stormwater flowing into the sanitary sewer.

Acronym Legend

LEWS=	Lake Erie Watershed	DIV=	Diversion to NEORS
RRES=	Rocky River East Side	DB=	Detention Basin
RRWS=	Rocky River West Side	RD=	Redirection
GI=	Green Infrastructure (Permeable pavement, bioretention)	BLK=	Bulkhead
SC=	Source Control (Private and Public)	PS=	Pump Station
SS=	Sanitary Sewer Separation	REL=	Relief Sewer (San or Comb)
HRT=	High Rate Treatment	TBD=	To Be Determined



CHAPTER 9 – PRELIMINARY FINANCIAL ESTIMATES

9.1 BACKGROUND

The city's NPDES permit requires an assessment in terms of cost and effectiveness for a range of alternatives and control levels. This report provides the preliminary estimates contemplated for Phase 1 of the IWWIP with planning level cost estimates of the proposed and conceptually relevant control technologies. "Phase 2" will include more detailed costs estimates once a thorough review of the alternatives has been conducted by the city and a suite of control strategies is agreed upon.

Citywide Geographical Information System data, including the municipal boundary and sewer system information, was used to estimate the land area needed for each of the control strategies analyzed. The land area needed for each strategy aided in the development of the costs. Additionally, similar recently completed local construction projects were used as cost references when developing the IWWIP cost estimates. Specifically, this includes cost information from the Edgewater Drive Sewer Separation Project and the Source Control Pilot Study Project.

Costs are provided as a planning-level estimate and are based on construction costs as of the date of this IWWIP. The goal of this cost estimate is to provide a general understanding of the financial requirements necessary to implement the proposed control strategies. Life-cycle costs, which can be especially significant in the case of green infrastructure, will be analyzed in the Phase 2 IWWIP.

9.2 SEWER SEPARATION (IN COMBINED SEWER AREAS)

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, sidewalks, and landscaping. The new sanitary sewer line intercepted and separated storm and sanitary flows of approximately 80 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 linear feet (LF) of sewer. These total project costs ended up breaking down to approximately \$770/LF of public sewer installed.

The Source Control Pilot Study quotes averaged about \$8,000 to make the private property improvements necessary to prevent extraneous inflow and infiltration from occurring, and therefore provide a basis to estimate costs of corrections and improvements on private property.



Sewer separation was evaluated in the combined sewer areas, which includes approximately 3,226 homes and 75,870 linear feet, for a total cost estimate of \$84.2 million.

9.3 STORAGE TUNNELS OR BASINS

A detention basin is a technology that is one of the alternatives being considered to reduce overflows from LEWS1035-A (CSO 059) by throttle flows from the east end of the system. This storage basin is the only storage basin included in the IWWIP. Recent analysis of completed regional projects suggests a cost of approximately \$4/gallon could be expected. This does not include any soft costs such as land acquisition or engineering, and assumes average soil conditions for a below ground, concrete, structurally reinforced tank. A 15 million gallon storage facility could cost approximately \$60 million to construct.

9.4 EXPRESS SEWERS

No express sewers were evaluated as a part of the IWWIP because there are no significant upstream areas where separate sanitary sewers are contributing to CSOs.

9.5 INCREASED TREATMENT CAPACITY

The High Rate Treatment analysis described in Appendix E included a planning level capital cost estimate, and a summary is provided below for reference in Table 9-1. More detail regarding the design intent, operation, and maintenance can be found in the High Rate Treatment Basis of Design (Attachment E).

**Table 9-1: HRT Capital Costs**

Description	Cost
Site Construction	\$ 971,000
Concrete	\$ 1,280,000
Masonry	\$ 1,176,000
Metal Fabrications	\$ 368,000
Process	\$ 7,949,000
Electrical and Mechanical	\$ 2,055,000
Siphon and Outfall Modifications	\$ 1,000,000
Total Capital Cost	\$ 14,799,000

Additionally, daily operation and maintenance costs were estimated at \$0.19/1,000 gal or \$6,803/operating day of 35 mgd flow.

9.6 PROPOSED IWWIP

This section addresses multiple items in the permit, including: “Combination of Multiple Alternatives,” “Control Strategies Achieving 4 or Less Overflow Per Typical Year,” and “Control Measures to Eliminate Sanitary to Storm Cross Connections” at local and citywide levels. In order to address the system as a whole, the application of both green infrastructure and source control were used in forming the IWWIP. Costs for each of those are provided at a planning level below.

Source control, in over-under sewer areas, was the prevalent control strategy used in the IWWIP Hydraulic Model to eliminate cross connections between the sanitary and storm sewers. Source control was used in combination with green infrastructure and the rest of the suite of technologies explained in Chapter 8 to bring the city to four or fewer overflow events in a typical year of rainfall.

9.6.1 GREEN INFRASTRUCTURE COSTS

Green infrastructure is identified as a single feature shared by the tree-lawn, sidewalk and driveway apron within the right of way. Several planning-level costing analysis references were used to understand potential costs, including cost evaluations from the City of Lancaster, Pa., the Minnesota Stormwater Manual, the State of Maryland Department of Environment & University of Maryland, and a study by ECONorthwest. These costs varied due to the differences in assumptions made and level of detail which each approach utilizes. General costs for this specific green infrastructure are estimated at \$11,700 per



lot. An estimated 3,226 lots could be ultimately included in the IWWIP results in a cost of approximately \$37.7 million. Table 9-2 compares conceptual costs of performing green infrastructure versus sewer separation in the same combined sewer areas with 3,226 homes.

Table 9-2: Sewer Separation vs. Green Infrastructure (Construction Only)

Sewer Separation Cost	Unit Type	Unit Cost	Units	Total Cost Estimate
Public Side	LF	\$ 770.00	75,870	\$ 58,420,000
Private Property	LOT	\$ 8,000.00	3,226	\$ 25,808,000
Sewer Separation Subtotal				\$ 84,228,000
Green Infrastructure Cost	LOT	\$11,700.00	3,226	\$ 37,744,000

9.6.2 SOURCE CONTROL COSTS (OVER/UNDER SEWER AREAS)

Source control costs can be broken into two segments; private sewer corrections and public sewers. The pre-construction private property costs were budgeted in the Source Control Pilot Study Project at \$8,000 per property. The actual per home costs varied depending on the presence of foundation drains, the condition of the laterals, and the number of cross connections. The public sewer separation costs associated with the pilot project were essentially equal to those of the private side, in effect doubling the cost to about \$16,000 per property. An estimated 7,682 parcels would be included in the source control technology areas, totaling \$123 million.

9.7 IWWIP COSTING SUMMARY

In addition to the citywide approaches of green infrastructure and source control, Table 9-3 includes other proposed improvements, as suggested in Chapter 8.

**Table 9-3: IWWIP Phase 1 Conceptual Capital Cost Summary**

Control Strategy	Planning Cost Estimate
HRT	\$ 14,800,000
Source Control	\$ 123,000,000
Green Infrastructure	\$ 37,700,000
East End Detention Basin	\$ 60,000,000
CSO-055 Separation	\$ 3,500,000
LEWS1140-E Victoria Ave Separation	\$ 1,600,000
Pump Station: Edgewater & Homewood	\$ 500,000
Pump Station: Edgewater & Nicholson	\$ 500,000
Subtotal	\$ 241,600,000
15% Contingency	\$ 36,240,000
Planning Total	\$ 277,840,000

Table 9-4 compares the IWWIP Conceptual Cost Estimate to other previous control plans.

Table 9-4: Conceptual Cost Comparison

Approach	Planning Level Cost in 2016 Dollars
2006 LTCP	\$478 million
IWWIP	\$277.8 million



CHAPTER 10 – IWWIP PLANNING AND CONTINUED IMPLEMENTATION

10.1 PHASE 2 IWWIP PLANNING

This Phase 1 IWWIP is a preliminary plan based on the analysis and public engagement to date. Lakewood recognizes that there will be no pause in its ongoing efforts to advance this Phase 1 IWWIP into the Phase 2 IWWIP, which must be completed by March 2019.

Lakewood’s NPDES permit mandates that Lakewood complete the following activities within the specified deadlines in the next 2.5 year window:

1. Submit an application for a Permit to Install (PTI) for the “Initial Control Measure” which will be a ballasted flocculation high rate treatment system. The PTI is scheduled to be submitted in March 2018.
2. A final IWWIP will be due in March of 2019. The following will be included in that plan:
 - a. All modeling updates
 - b. Final evaluation of the Source Control Pilot Study effectiveness
 - c. Updated evaluation of all alternatives in terms of:
 - (i) Costs
 - (ii) Effectiveness (discharges, discharge volumes, pollutant loadings)
 - d. Recommend a set of alternatives
 - e. Recommend an implementation schedule
 - f. Complete a financial capability assessment
 - g. Complete a sewer rate study

The financing and scheduling components of the Phase 2 IWWIP represent new territory for the City of Lakewood. This IWWIP will be the largest and most expensive infrastructure program in the city’s history. As such, new financing tools are under investigation, and the city will have a robust public discussion on the equitable approaches to funding the new program.

In completing its Phase 2 IWWIP, Lakewood will also build off its success in engaging the community and integrating its wet weather goals into its municipal codes and operations. Lakewood understands this integration as essential to maximizing cost-effectiveness of a program that represents a challenge to its financial sustainability.



10.2 INTEGRATED PLANNING TOOLS IN USE

Lakewood has put into practice tools from Integrated Planning tool box that will enable it to sustain the progress made during this Phase 1 IWWIP and deliver on the Phase 2 IWWIP when it is complete. In many ways, Lakewood's experience is unique in using these tools, as described below.

10.2.1 LAKEWOOD'S COMMUNITY VISION INCLUDES STORMWATER GOALS

Lakewood in 2012 completed an expansive public discussion that led to a revision of its community vision. The Lakewood's Community Vision (<http://vision.onelakewood.com>) is an expression of the community's goals and was adopted by City Council in 2012 following dozens of community meetings, and input from hundreds of Lakewood constituents.

The Community Vision has six broad focus areas: Commercial Development, Housing, Community Wellness, Education & Culture, Mobility and Safety. Each focus area has a vision statement, goals and objectives. Below are examples of integrating stormwater planning in the Vision:

Community Wellness Focus Area

- Vision statement: Support healthy living and create a more ecologically sustainable city
- Goal: Adopt environmental best practices, e.g. greening of Lakewood, recreation/open space, cost effective redevelopment
- Objective: Consider small-scale community-based solutions to help alleviate storm runoff including the use of rain barrels, bio-swales, stormwater retention, and permeable pavements
- Objective: Educate about the responsibility of maintaining sewers citywide
- Objective: Use community based solutions to address source control

Commercial Development Focus Area

- Objective: Promote the use of stormwater management techniques such as bio-swales, rain gardens, and pervious pavements in commercial districts

The Community Vision serves as the city's comprehensive plan and controls how Lakewood implements many of its code provisions, especially relating to land use.



10.2.2 PARKING CODE UPDATE

The Planning Commission's consideration of variances or other decisions require analysis of how an application comports with the Community Vision. For example, in 2014, the Department of Planning & Development, Planning Commission, and City Council worked together to rewrite Lakewood's parking code. The main purpose was to establish flexible vehicle parking requirements that support the Community's Vision. It was important for Lakewood to formally link parking to other initiatives and goals as stated in the Vision, including stormwater management best management practices, as parking regulations have a lasting impact on cities and neighborhoods. Two examples in the parking code directly related to stormwater management are the options a property owner/applicant has in relation to meeting the minimum or maximum parking requirements (ordinances 1143.10 and 1143.11):

The number of parking spaces required may be reduced in accordance with the following credits as determined by the Commission:

- Improvements to the property that may reduce carbon emissions and improve energy efficiency using environmental best management practices (BMPs) promulgated by the Environmental Protection Agency;
- Stormwater management techniques such as bioswales, rain gardens, and pervious pavements.

The number of parking spaces provided may exceed the maximum specified per the following options as determined by the Commission.

- Implementation of additional measures that control the flow of stormwater runoff on the project site pursuant to BMPs by providing and treating or controlling an additional volume above the computed Water Quality Volume as determined by Chapter 1339.

As part of the parking code rewrite, the city also made a small but important modification to allow for the Building Commissioner to approve final surfaces of all parking lots and areas used for access to parking lots. This allows for the implementation of innovative materials such as permeable pavers and porous concrete.

10.2.3 ARCHITECTURAL BOARD OF REVIEW AND STORMWATER MANAGEMENT

Consistent with the city's charter and the Community Vision, Lakewood's Architectural Board of Review (ABR) incorporates stormwater management into its review of new construction and major rehabilitation projects. Specifically, ABR is tasked with reviewing and approving landscape plans and it regularly encourages developers to utilize land-



scaping to help achieve compliance with the Lakewood's stormwater management regulations.

10.2.4 CONDITIONAL USE ZONING

The city has also demonstrated an effective link between conditional use permit applications and stormwater management. The Planning Commission reviews all conditional use permit applications, and is charged with determining whether applications are consistent with the Vision. The Planning Commission has the option to link its conditional use approvals to developers demonstrating stormwater management best practices. In Lakewood's built out environment, conditional use approval has required not only installation but ongoing maintenance of stormwater BMPs on private property.



Figure 10-1: Bioswale at Local Restaurant, Installed in 2014

10.2.5 LAKEWOOD STORMWATER ORDINANCE

As explained below, one of the biggest drivers of new green infrastructure installation in Lakewood has been the Lakewood ordinance that requires stormwater mitigation for any project that disturbs more than 8,000 square feet. Lakewood's old parcel allotment con-



sists of a majority parcels being well-below the 43,560-square-feet (one-acre) threshold at which state and model stormwater regulations apply.

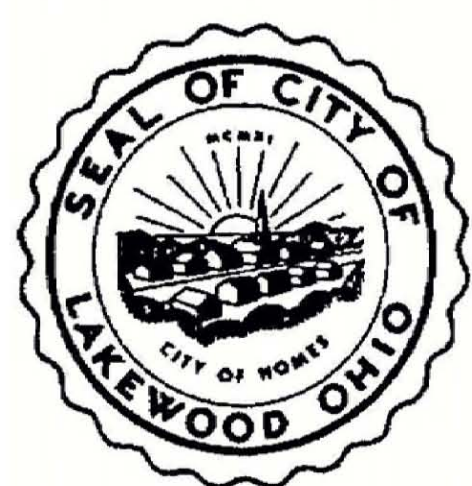
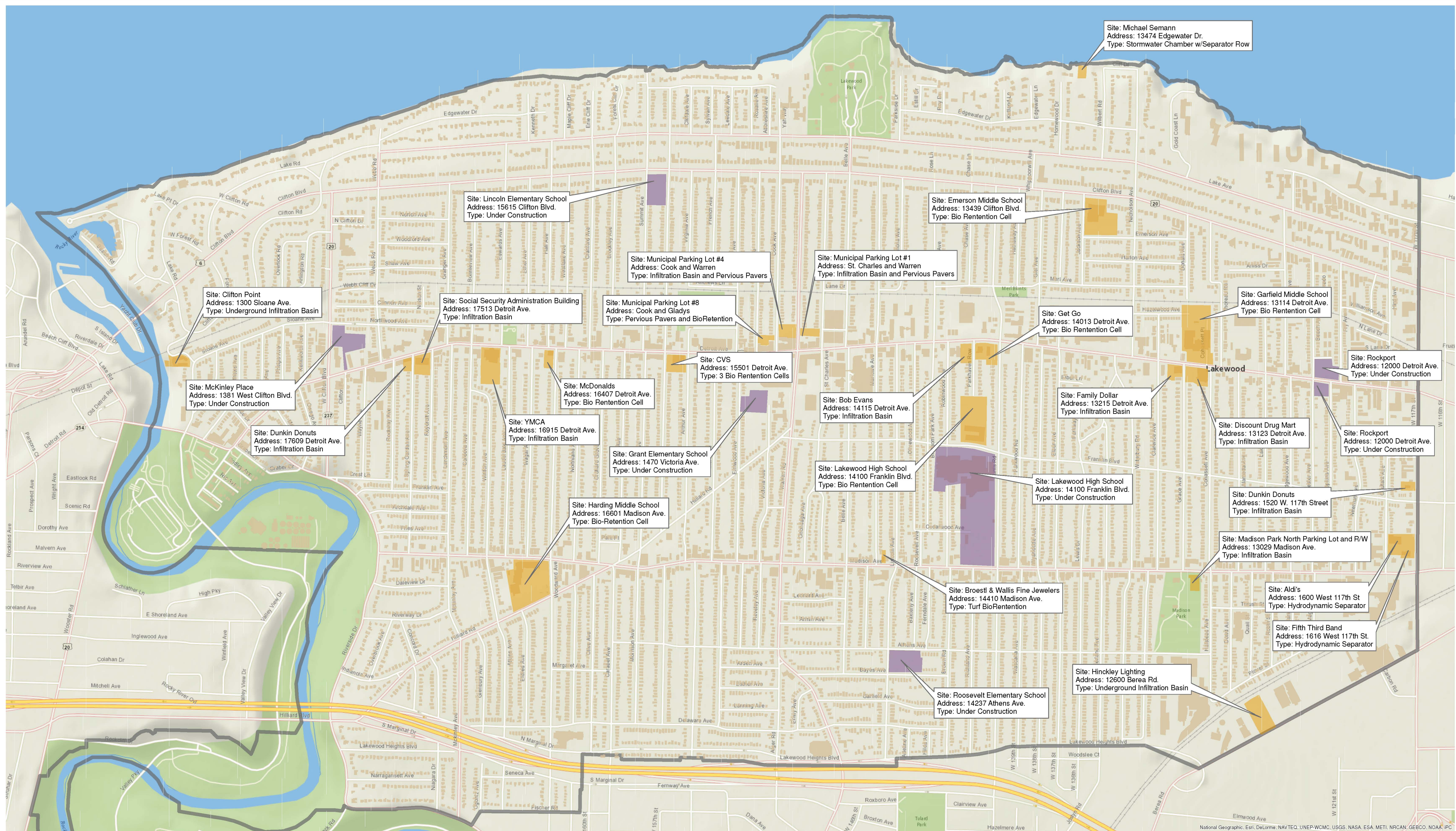
10.3 ACTIVE FOCUS ON STORMWATER GOALS LEVERAGES GREEN INFRASTRUCTURE

Lakewood's ordinances, codes and its active focus on stormwater in all development conversations have led in recent years to several green infrastructure installations. Twenty-two green infrastructure practices are already installed and six more are in the process of being installed (Table 10-1 and Figure 10-2, following page). Approximately 50 percent of these BMPs are installed on commercial property. In a century-old city that has little green space and a high percentage of impervious surfaces, these additions of new green infrastructure are significant.

The city utilizes Codified Ordinance Chapter 1339 to regulate the maintenance of post-construction BMP sites on city and private property. Post-construction BMPs are required for sites disturbing 8,000 square feet or more, which is a substantially smaller area than the 43,560 square feet (1 acre) that Ohio identifies as the minimum disturbance area. Numerous commercial properties have placed BMPs on their properties since this ordinance passed. Approved plans include language stating that the operation, maintenance, replacement and ownership of the post-construction BMP are required in perpetuity by the property owner. Annually, each site with a post-construction BMP is inspected by the Cuyahoga Soil and Water Conservation District (CSWCD) under contract with the City of Lakewood.

A report of findings is created for each site and forwarded to the City Engineer. When maintenance is required on city-owned BMPs, the report is provided to the Public Works Department for scheduling and completion. The City Engineer is notified upon completion.

For privately owned BMPs, a cover letter with the report is provided to the property owner and/or the property owner's representative. The cover letter provides a deadline to complete any required maintenance along with invoice for the inspection fee, which is set by the ordinance. Upon completion of the maintenance item(s), the property owner submits documentation of the work completed. Should there be any compliance issues, the City Engineer works with other city departments and the responsible parties to assure compliance. The Division of Engineering and Construction currently maintains a database of post-construction BMPs in the city's GIS mapping system for both city-owned and privately owned sites.



2016 Post Construction Stormwater BMP Sites

Department of Public Works
Division of Engineering



A great place to call home
Prepared by: J.C. Eschen
Date: June 2016
Base map: ESRI National Geographic
N:\GIS\ENGINEERING\LAYERS\POST CONSTRUCTION BMP

**Table 10-1: Green Infrastructure Practices in Lakewood, Ohio**

Name	Location	Property > 1 Acre	Property	Type of GI
Aldi's	1600 West 117th	Yes	Private	Hydrodynamic Separator
Bob Evans	14115 Detroit Ave	No	Private	Bioretention
Broestl& Wallis Fine Jewelers	14410 Madison Ave	No	Private	Turf Bioretention
Clifton Pointe	Sloane Ave	Yes	Private	Hydrodynamic Separator & Bioretention
CVS	15501 Detroit Ave	Yes	Private	Bioretention
Discount Drug Mart	13123 Detroit Ave	Yes	Private	Bioretention
Dunkin Donuts	17609 Detroit Ave	No	Private	Infiltration Basin
Dunkin Donuts	1520 West 117th	No	Private	Infiltration Basin
Family Dollar	13215 Detroit Ave	No	Private	Infiltration Basin
Fifth Third	1616 West 117th	Yes	Private	Hydrodynamic Separator
Get Go	14013 Detroit Ave	Yes	Private	Reduce Impervious/Stormwater Basin
Hinckley Lighting	12600 Berea Rd	Yes	Private	Underground Infiltration Basin
McDonalds	16407 Detroit Ave	No	Private	Bioretention
Social Security Office Building	17513 Detroit Ave	Yes	Private	Infiltration Basin
YMCA- Lakewood	169156 Detroit Ave	No	Private	Infiltration Basin
Michael Semaan	13474 Edgewater Dr	No	Private	Stormwater Chambers w/Separator Row
Emerson Elementary School	13439 Clifton Blvd	Yes	Public	Hydrodynamic Separator
Garfield Middle School	13144 Detroit Ave	Yes	Public	Bioretention
Harding Middle School	16601 Madison Ave	Yes	Public	Bioretention
Madison Park	13028 Madison Ave	No	Public	Bioretention
Municipal Lots 1 and 4	Detroit Ave btwn St. Charles & Cook	No	Public	Permeable Pavers & Bioretention
Municipal Lot 8	Detroit Ave btwn Cook & Gladys	No	Public	Permeable Pavers & Bioretention
Under Construction				
Rockport Phases 1B & 3	12000 Detroit Ave	Yes	Private	In process
McKinley Place	1381 W. Clifton Blvd	Yes	Private	In process
Lakewood High School	14100 Franklin Ave	Yes	Public	In process
Grant School	1470 Victoria Ave	Yes	Public	In process
Lincoln School	15615 Clifton Blvd	Yes	Public	In process
Roosevelt School	14237 Athens Ave	Yes	Public	In process



10.4 ADDITIONAL GREEN INFRASTRUCTURE ACTIVITIES

10.4.1 CITY-OWNED GREEN INFRASTRUCTURE INSTALLATION



Figure 10-3: Bioswale at Public Park, Installed in 2015

Within the last five years, Lakewood has installed BMPs at four municipally-owned parking lots and a BMP along a stretch of Madison Avenue roadway that treats roadway runoff. These installations provide further demonstration of stormwater practices in Lakewood. They are also good examples of Integrated Planning, as the required capital investment was tied to stormwater improvement and, through advance planning, was able to leverage some grant funding, keeping the projects cost-effective.

10.4.2 TRAINING ON GREEN INFRASTRUCTURE

Annually, the City Engineer provides training to city personnel as part of the city's NPDES MS4 permit (MCM No. 6: Pollution Prevention and Good Housekeeping).

Accordingly, on March 21, 2016, 15 City of Lakewood employees attended an introductory workshop on GI maintenance, which included both class instruction and field demonstration. This training was given by the CSWCD. The Lakewood attendees includ-



ed: Groundskeepers, Park Managers, Group Leaders, the City Engineer, and the Director of Public Works. The introductory workshop focused on bioretention maintenance.

An example of a bioretention inspection and maintenance checklist provided by Cuyahoga County Soil and Water Conservation District is provided below. This type of a checklist is potentially a template for Lakewood maintenance crews to follow to ensure proper functioning of GI.

Bioretention Area Inspection and Maintenance Checklist

Facility:			
Location/Address:			
Date:	Time:	Weather Conditions:	Date of Last Inspection:
Inspector:		Title:	
Rain in Last 48 Hours ☐ Yes ☐ No If yes, list amount and timing:			
Pretreatment: ☐ vegetated filter strip ☐ swale ☐ turf grass ☐ forebay ☐ other, specify: ☐ none			
Site Plan or As-Built Plan Available: ☐ Yes ☐ No			

Inspection Item		Comment	Action Needed
1. PRETREATMENT			
Sediment has accumulated.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Trash and debris have accumulated.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
2. DEWATERING			
Standing water is present after 24 hours. If yes, describe sheen, color, or smell.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
3. INLETS			
Inlets are in poor structural condition.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Sediment has accumulated and/or is blocking the inlets.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Erosion is occurring around the inlets.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
3. VEGETATION			
Vegetation is wilting, discolored, or dying due to disease or stress.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Vegetation needs to be controlled through mowing or manual removal.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
4. BIORETENTION MAIN INFILTRATION AREA			
Trash and debris have accumulated.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Sediment has accumulated at the surface.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Topmost layer is caked or crusted over with sediment.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Erosion is evident.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Mulch is compacted.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Sinkholes or animal borrows are present.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
5. SIDE SLOPES AND EMBANKMENT			
Erosion is evident.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Sinkholes or instability is evident.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
6. OUTLETS AND OVERFLOW STRUCTURE (i.e., catch basin)			
Outlets or overflow structures in poor structural condition.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Sediment, trash or debris is blocking the outlets or overflow structure.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Erosion is occurring around the outlets or overflow structure.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No
Height from surface of practice to top of overflow structure is insufficient to allow for ponding during rain events.	☐ Yes ☐ No ☐ N/A		☐ Yes ☐ No



WHEREAS, green stormwater infrastructure includes the use of vegetation and landscaping, rainwater harvesting, and permeable surfaces to capture, detain, filter, and infiltrate stormwater runoff; and

WHEREAS, stormwater infrastructure is recognized as an effective way to: reduce combined sewer overflows, reduce stormwater peak runoff volumes, reduce local flooding, and improve the quality of surface runoff, all for a typical year of rainfall; and

WHEREAS, stormwater infrastructure can provide cost-effective solutions to stormwater management when practiced at a citywide scale, such that these facilities can cumulatively reduce runoff volumes to the extent that the need to enlarge existing piped infrastructure is reduced or eliminated for a typical year of rainfall; and

WHEREAS, coordinating stormwater infrastructure installation with broader transportation improvements can significantly reduce the marginal cost of stormwater management by including it within larger infrastructure improvements; and

WHEREAS, using public space as locations for stormwater infrastructure alleviates the need for obtaining permission to access private property; and

WHEREAS, stormwater infrastructure approaches foster unique and attractive streetscapes that protect and enhance neighborhood livability.

921.01 TITLE

This ordinance shall be known as the “Stormwater Infrastructure Ordinance” and may be so cited.

921.02 RULES ESTABLISHED

Rules and regulations for the installation, management, control, and protection of stormwater infrastructure located in the public right-of-way, namely driveway aprons, sidewalks, and tree lawns, as well as on other public property, are hereby established in this chapter.

921.03 APPLICABILITY; LIMITATIONS AND EXEMPTIONS

- (a) Stormwater infrastructure will be used primarily on streets with combined sewers and in any other area identified by the city that would benefit from stormwater infrastructure.



- (b) Exemptions to be considered include, but are not limited to, technical infeasibility. When, as determined by the Director of Public Works and City Engineer, the on-site stormwater infrastructure requirements are technically infeasible, the infeasibility shall be demonstrated and reviewed in consultation with other appropriate departments. The technical infeasibility may result from conditions that may include, but are not limited to:
 - 1. Brownfield development sites or other locations where pollutant mobilization is a documented concern;
 - 2. Locations with potential geotechnical hazards;
 - 3. Locations with severe topographic or natural resource constraints; or
 - 4. Locations where existing structures and utility conflicts do not allow for implementation of stormwater infrastructure.

921.04 MAINTENANCE

- (a) All projects governed by this ordinance shall include provisions for permanent and ongoing maintenance of the stormwater infrastructure. The city shall establish a level of service for routine, on-going operations and maintenance needs of all stormwater infrastructures to ensure long-term proper functioning.
- (b) The maintenance program shall include the mapping of the location and installation details of each stormwater infrastructure facility installed.
- (c) Sidewalks, tree lawns, and driveway aprons with stormwater infrastructure installed, based on the plan, shall be the city's responsibility for the repair and maintenance of such sidewalk, driveway apron and tree lawn when required by normal usage. In situations where damage is created by others, the responsible party shall bear the costs of the incurred damages.

921.05 DESTRUCTION OF PROPERTY

No person shall remove, destroy, mutilate or deface in any way any tree, shrub, fern, plant, flower, permeable surface, or other property in any stormwater infrastructure facility.

921.06 OBSTRUCTING FLOW

No person shall install barriers or otherwise obstruct the flow of water into the stormwater infrastructure facilities. No person shall place any straw, dirt, chips,



paper, shavings, shells, ashes, swill or garbage, or other rubbish, in or upon the same, in any stormwater infrastructure facility, except by permit issued by the Director of Public Works.

921.07 DESIGN GUIDELINES

It is a goal of the plan to develop its own technical design standards, specifications, and guidance documents to ensure consistent and meaningful compliance with this ordinance.

10.5 PUBLIC PARTICIPATION EXPANDS

Consistent with Lakewood's Community Vision and EPA's Integrated Planning Framework, Lakewood will continue its active public engagement during the development of Phase 2 of the IWWIP. The city continues to engage with the Clean Water Lakewood (CWL) Task Force and hopes that those committed members and new members will continue to participate in the meetings regarding the city's water and sewer issues. Lakewood also actively maintains its Clean Water Lakewood website with topically-relevant materials.

Lakewood City Council will hold public proceedings at multiple junctures during the development of the Phase 2 IWWIP.